INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 | Chicago, October, 1924 | *Number 10*

These Pictures Speak Louder Than Words—

One Job Shows That the Other Has Little Justification and How Easily It Could Be Revamped

NOT so long ago I was in Greenville, S. C., and called on my good friend, R. S. Huntington, who is president of Huntington & Guerry, one of the largest mill contracting firms in the South. R. S. H. is chock full of construction ideas and every time I see him he has something new to spring. Among the things he showed me this time was the arrangement of primary and secondary wiring for the small transformer substation shown in the accompanying photo. The idea is so good and so simple that I want to pass it on to those of you who may have an installation, such as shown in the upper photo, that has been an eyesore for a long time and you have not taken the time to revamp it.

Whenever I see an unsightly mess of outside wiring like that in the top photograph, I can't help but think of the grief some fellow may have after a heavy sleet storm trying to patch up a hopeless tangle of dangerous wiring. But the scheme devised by R. S. H. as shown here points a way to a real job that will stay put as long as the transformers will last. It will be noticed that the pipe frame anchored in the concrete foundation for the transformers, serves both as a guard and a means of drawing the primary bus cables up tight. The same idea is used for the secondary bus cables, so that connections to the primaries and secondaries of the transformers are flexible yet rigid enough to withstand the severest strains that may be caused by storm, snow and sleet. Note also that conduit is used as far as possible and that it is supported in a permanent fashion so that no wires are left dangling to be whipped about and finally broken.

It's perhaps unnecessary to compare these two installations since they speak for themselves. The one is a fine looking job and the other a dilapidated mess of wiring, the like of which can be found too often at the rear of a plant where few people see it. If you have such an eyesore, I hope this idea of R. S. H.'s will inspire a cleaning-up job. Sometimes all that is needed is a suggestion like this and a free Saturday afternoon or Sunday to give a new birth to a job that has been in mind for a long time. If these photos do cause such action and you work out a good looking job, take a picture and send it to me with or without a picture of what it looked like before you started. Or if you have already devised a scheme similar to that of R. S. H.'s, send that along and let me show you how you yourself can get some credit for an original idea and the ambition to do good housekeeping around your plant. You can't afford to give the impression that messy wiring and sloppy patchwork represents the kind of thinking you do. On the other hand, good installations well kept up are a just cause of pride and good insurance against unexpected failures and the grief that goes with them.

Practical Pete

A Glimpse into the Plants of

The Chicago Tribune Company

Which publishes and delivers over 600,000 copies daily and 900,000 copies on Sunday in Chicago and over 800,000 copies daily and Sunday of the Daily News in New York, as well as 600,000 copies of Liberty, a weekly magazine

ONE OF the best examples of the value of giving careful attention, inspection and maintenance lies in the printing presses of our metropolitan daily newspapers. In order to get papers on the street and in the mail at fixed times and still report the late news, presses must operate against a very close schedule. Between runs the press is gone over carefully so that it is ready to go without interruption when once started.

Other complicated mechanisms in connection with a large publishing establishment are the linotype and monotype machines, which set and cast type mechanically by the operation of a keyboard, and the machinery for paper production. The accompanying illustrations give some idea of their size and complexity.

Newspapers have become such a daily institution as to be regarded almost as a necessity. Statistics show that at the end of 1923, there were 426 English-language morning newspapers with 11,500,000 circulation, 1,610 evening papers with 20,000,000 circulation and 547 Sunday papers with 21,500,000 circulation. In addition, a large number of semi-weekly, weekly and more or less frequent local newspapers are published.

This will soon be the new home of The Chicago Tribune.

Tribune Tower is now under construction and will be occupied early in 1925. This is the design which won the $50,000 prize in a competition among the world's architects. The building will rise 456 feet above Michigan Blvd. Some of the presses are already installed and the building is being constructed around them.

One of the largest newspaper plants in this country is operated by The Chicago Tribune Company, Chicago, Ill., publishers of The Chicago Tribune, the Daily News (New York City) and Liberty, a weekly magazine. Each of the two newspapers has the largest morning circulation in Chicago and New York, which totals 1,400,000 copies daily.

The Chicago Tribune was first published in 1847 when Chicago had a population of 16,000 and only one railroad. Since then it has missed publication only four times—two days due to a fire in 1849 and two

Steps in the making of paper for The Chicago Tribune and the New York Daily News.

The Chicago Tribune Company has 500 sq. mi. of pulp land far up on the Gulf of St. Lawrence. This timber is cut in winter and floated down to the Gulf in the Spring where it is loaded on boats and hauled down to the paper mill at Thorold, Ontario, near Niagara Falls. The illustration at the left shows how the logs are lifted from the deck of a steamer and thrown into the pond at the paper mill. They are floated across the pond, sawed into 4 ft. lengths, and then built up into huge storage piles. One of the first steps in the making of paper is grinding the pulp wood. The workman (lower left) is inserting a log into a grinding machine. Below is part of the paper mill for making newsprint.

The linotype room and the matrix tables.

This is part of the battery of 59 linotype machines used in the plant of The Chicago Tribune. Here each line of text is cast on a slug. As the operator touches the key board the machine selects the proper letters from the magazine, places them in sequence, automatically equalizes the space between the words, casts the words in a slug of a single line, and then distributes the original type mold or matrix back into its proper place in the magazine to be used again. After the reading matter is assembled into pages, along with the advertisements, the whole is locked into a steel form and brought to the matrix tables shown at right. Here a thick mat, made up of several thicknesses of special paper, is placed on top of the type and a pressure of 15,000 lb. applied. This impression forms the molds for casting the stereotype plates, which are used in printing.

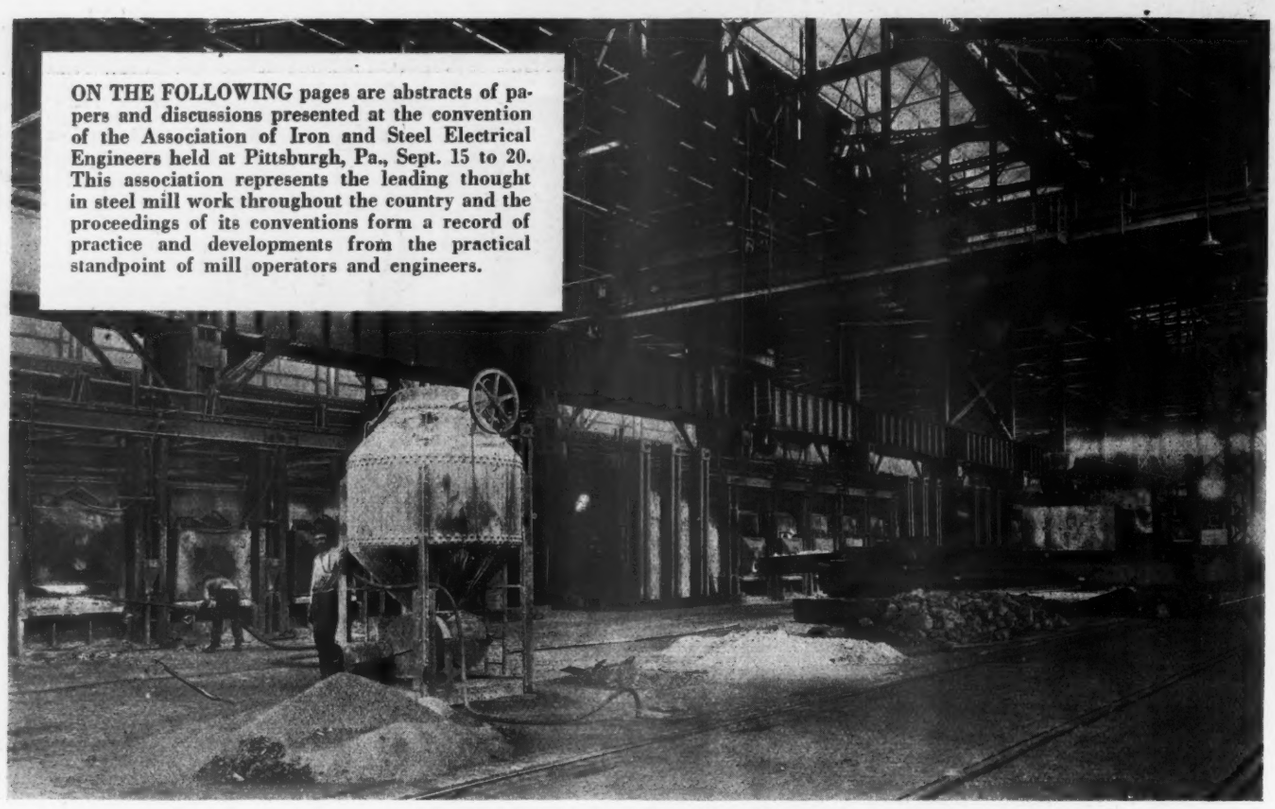
days at the big Chicago Fire in 1871, both of which destroyed the entire plant. But the growth during that time has forced the Tribune to move into larger quarters several times. It is now building a complete new office building and publishing plant.

Since publication is entirely dependent upon a supply of paper, The Chicago Tribune Company some years ago purchased 500 sq. mi. of timber land far up on the Gulf of St. Lawrence. It also established a paper mill at Thorold, Ontario, not far from Niagara Falls. The pulp logs are cut in the winter, floated down to the Gulf in the spring and then shipped to the paper mill. Last year about 93,500 tons of paper were used by The Chicago Tribune alone.

The problems of newspaper publishing are seldom realized by those not familiar with the industry. The fact that practically all news and advertising in the paper comes into the office, much of it by wire from all over the world, is rewritten, edited, set in type, stereotyped and printed all within a day and much of it in the late afternoon and evening, gives some idea of the work and the equipment involved. Since news a day old is no longer news, the equipment must be maintained in such shape that it will always function.

Two views in the press room of The Chicago Tribune plant.

Despite the intricate mechanism of these presses, practically the only interruptions are due to breakage of paper. This is largely due to the careful attention given to them every day while idle. When operating at full speed, each press will deliver 600 Tribunes per minute, or two complete newspapers for each revolution of the cylinder. The newspaper presses are 230 ft. long. Each unit, or the whole press may be controlled by push buttons placed within convenient reach of the pressman. The papers as finished are folded and carried on a special conveyor, shown just behind the man in the illustration below, across to the mailing room. The maximum press capacity is 1,130,000 40-page Tribunes daily.



ON THE FOLLOWING pages are abstracts of papers and discussions presented at the convention of the Association of Iron and Steel Electrical Engineers held at Pittsburgh, Pa., Sept. 15 to 20. This association represents the leading thought in steel mill work throughout the country and the proceedings of its conventions form a record of practice and developments from the practical standpoint of mill operators and engineers.

Details of the

Topics Discussed by Steel Men

At the Convention of Association of Iron and Steel Electrical Engineers Held Last Month at Pittsburgh, Pa.

PRACTICALLY every important phase of steel mill operation had a place on the program of the annual convention of the Association of Iron & Steel Electrical Engineers held at Duquesne Garden, Pittsburgh, Pa., September 15 to 20. In the main, the papers were free from theoretical viewpoints and dealt with the practical phases of steel-mill problems that are now being faced or have been successfully worked out during the last two years.

Abstracts of the principal papers are presented in what follows. The main points brought out by different steel mill operators in their discussions of these papers are given in the reports beginning on page 474.

Maintenance Practice in Steel Mills

Discussion Conducted By

A. C. CUMMINS

Electrical Superintendent, Carnegie Steel Company, Duquesne, Pa.

THE following outline of the different maintenance operations usually carried on in steel mill shops, was forwarded to the members of the Association with the request that they go over this matter carefully and come to the convention prepared to take part in the discussion of the subjects outlined.

(1) GENERAL MOTOR REPAIR SHOP PRACTICE.

(a) Shop cleaning of equipment received for repairs. Best and most economical method.

(b) Inspection and test of equipment returned for repair; procedure and practice.

(c) Do you advocate running test of repaired equipment as final test?

(d) Has the apprentice system of training shop personnel proved satisfactory?

(2) ARMATURE REPAIR PRACTICE, D. C. EQUIPMENT:

(a) Should all armatures arriving at shop with one or more damaged coils be rewound, or should damaged coils be replaced without complete rewind? Have you any definite data on this subject?

(b) Should damaged commutators be repaired at mill shops, or is it more economical to return damaged commutators to manufacturer for repair? What shop equipment is necessary for a good commutator job?

(c) What increased service has been obtained by the adoption of the dipping and baking process in treating armatures to give better insulating qualities? Have you any objections to the use of this process? Definite figures on this subject are very desirable.

(d) Have you adopted anything new to prevent breaking of armature leads in wire wound coils? What is best practice in reinforcing broken leads on

armatures which give trouble in this respect?

(e) What is best practice in reference to shafts in regard to the following:

1. Bent shafts.
2. Worn journals.
3. Worn pinion fits.
4. Bad keyways.

(f) Commutators:

1. Do factory commutators prove sufficiently superior to justify the additional cost?
2. Do you advocate purchasing assembled bars or complete commutators mounted on bushings?
3. Do you know of any oil-proof paint or cement which will delay damage to commutator insulations caused by oil or grease?
4. Have you any application where undercutting does not seem practicable?
5. Do high-grade brushes bring any tangible returns in increased commutator life?

(g) What is best practice regarding bearings in the following details:

1. What is permissible radial wear in d. c. armatures?
2. What is permissible radial wear in induction motors?
3. Have you found any quick way, that is dependable, to inspect bearings for radial wear?
4. In rebabbitting shells is it always necessary to first tin shells as recommended by manufacturers?
5. Do you use any special care in handling babbitt? If a change in babbitting has recently been made have you noted any superior service? Does pyrometer equipment actually enable babbitt men to do enough better work to justify the investment?
6. Do modern babbitt bearing designs eliminate oil from armatures? What does shop observe?

(h) What is best practice with antifriction bearings in regard to the following:

1. Removal from shafts without damage?
2. What is their ultimate life? How should greasing be handled?
3. Do motors equipped with antifriction bearings reach shop absolutely free of grease and oil on windings and commutators? More or less than latest babbitt bearing types?

(i) Coils.

1. Do you advocate electric shops equipping themselves to make their own coils? Let us hear your views on this subject.

(j) Assuming you are using a dipping and baking process of varnishing armatures what is the best practice in handling the following details:

1. Cleaning after winding, but before drying.
2. Drying, before dipping.
3. Dipping, how immersed, and for how long?
4. Do you know of any special varnish characteristics which have proved specially desirable?
5. How should excess varnish be removed? Why should it be removed?
6. What are the most satisfactory baking temperatures and baking times?

(3) A. C. STATOR PRACTICE—CORES.

(a) When is restacking necessary? How may it be avoided?

(b) Best practice in preparing cores for winding?

(c) Are riveted laminations proving superior to older designs?

WINDING PRACTICE.

(a) Insulation of slots.
(b) Coil insulation.
(c) Dipping and baking.
(d) Kinks.

ROTORS.

(a) Is welding squirrel-cage end rings to bars of old motors desirable?

(b) If so, are bars installed in slots bare, or is it best practice to use insulation as originally designed?

(c) In what way does shop practice in handling wound rotors differ from d. c. practice?

(d) Are there any reasons why dipping and baking are not desirable in wound rotors?

(4) CONTROLLERS.

(a) Should control be repaired by shop men or general mill maintenance men? Why? What is the extent of repair?

(b) If control is repaired in shop what provision is necessary for test and adjustment before storing as spare equipment?

(c) Should resistance be standardized? What steps have you taken to reduce the number of different grid sizes required?

(d) Have you any special "stunts" for handling control repairs?

(5) FINAL.

(a) How are shops to keep down investment in supplies? Some works have 50 per cent of their total electrical stores invested in armature coils. How can this be kept down?

(b) What proportion of running armatures should be stored as spares?

* * * *

Discussion on Maintenance Practice

The discussion of the questions presented by Chairman A. C. Cummins, centered around the problem of whether renewal and repair parts should be made in the steel plant repair shop or purchased from the motor or control manufacturer. Opinions differed, but the majority took the stand that renewal parts for modern equipment should be purchased, while the parts for the older and more or less obsolete apparatus could be handled to better advantage in the plant repair shop.

Mr. Cummins spoke of the necessity of determining accurate shop costs and the value of analyzing them. He has found the charges against motors of 40 hp. to 60 hp. in plants having 40,000 to 60,000 hp. of motors will range from $60 to $100 per year per motor. These charges include material, labor and overhead, such as executives' and foremen's salaries, storeroom costs and the like. Every means available should be used to reduce this overhead. One way to save is by careful collection and disposal of waste brass, copper and the like. This should be collected and credited to the electric shop.

A. J. Standing of the Saucon plant of the Bethlehem Steel Co. stated that a repair shop should confine itself to maintenance and repair and not attempt the manufacture of repair parts. Building new equipment or parts runs up the overhead charges because better and more skillful men are required for such work, to say nothing of the development work required in making the parts. The motor or control manufacturer can pay good prices for men to do this kind of work and absorb these costs in large production. He further stated that the plant electric shop should go as far into repair as possible, but should avoid the extensive making of coils, commutators and the like. W. T. Snyder of the National Tube Co., McKeesport, Pa., also stated that the manufacture of repair parts is outside the province of the repair shop.

G. E. Stolz said that the equipment manufacturer cannot answer the question as to what parts can best be made in the repair shop. It is a question of accounting. The shopman should obtain accurate data on the cost of making repair parts in his own plant and then carefully consider the life of the parts of his own manufacture as compared with the life of the manufacturer's parts. It comes back to a question of cost per year rather than cost per coil or per part.

On the other hand, F. W. Cramer of the Cambria Plant of the Bethlehem Steel Co. stated that a great deal of parts manufacture, particularly coil winding, is done at his plant. This works out advantageously when the plant is not located close to a large manufacturer and trouble is had in obtaining quick shipment of the necessary parts. He also said that the manufacturer's price of coils for old or obsolete motors is high. Consequently, all of this material is made at the plant. If such coils were bought and stored several years they would deteriorate so as to be worthless; hence the value of making them shortly before being used. At this plant an accurate record is kept of the cost of making coils; consequently they are in a position to know what coils they can profitably make. He stated that he was not able to show a saving in making coils for modern motors.

J. A. Morgan of the Edgar Thomson Works of the Carnegie Steel Co. stated that they manufacture coils in sizes up to 50 hp. They dip and

bake the coils but do not impregnate them.

Mr. Morgan advocated complete rewinding of damaged armatures unless the defects are very slight. Mr. Blakeslee stated that most armatures have to be completely rewound and that unless the coils are soft and flexible, most of the coils from a damaged armature have to be replaced.

Mr. Snyder said that some shops are not keeping step with other developments in the mill. Mr. Cummins advocated the use of commercial repair shops by small plants that are convenient to them.

In cleaning motors and equipment before being repaired, Mr. Standing stated that the equipment was blown out with compressed air. This was done outdoors and not in the shop. Other operators stressed the same point. The value of dipping and baking armatures after rewinding was acknowledged by several speakers.

Opinion was divided on the advisability of straightening bent shafts. Mr. Standing stated that he discarded bent shafts. John C. Reed of the Steelton (Pa.) plant of the Bethlehem Steel Co. and J. A. Morgan said that they straightened the smaller shafts after they had been bent. D. W. Blakeslee of the Jones & Laughlin Steel Corp. said the same practice was followed at his plant. All the men discussing the paper spoke of the successful use of arc welding for building up worn pinion fits, worn journals and damaged keyways. Mr. Morgan reported success in welding broken armature shafts.

Mr. Reed advocated a running test of repaired equipment — no-load tests, ground and high-potential tests being recommended.

Mr. Cramer spoke of the necessity for protection of armatures during the time they leave the motors until they reach the repair shop and likewise on their return trip. Since it is impossible to handle the armatures carefully in the steel plant they have made round steel cases which will hold the armature complete with its bearings. The armature is placed in this case and thus protected during transit to and from the repair shop.

He also mentioned that they do not change armature bearings in the field. All armatures are fitted with bearings in the shop and when an armature is changed the bearings are also changed.

Opinion was divided on the problem of commutator repair. Mr. Reed repairs a great many commutators. Mr. Blakeslee stated that it was more economical to repair commutators than to send them out. On the other hand, Mr. Morgan does very little commutator repair work and finds it advisable to have such work done in commercial repair shops.

Mr. Reed stated that he kept all of his commutators undercut, while Mr. Blakeslee felt that a damp location was undesirable for an undercut commutator. Mr. Reed also emphasized the economy resulting from the use of high-grade brushes.

In commenting on bearings he said that about $\frac{1}{32}$-in. radial play is permitted before discarding them. This play is determined by prying up the pinion with a bar and also by checking with feelers under the pole pieces. Mr. Blakeslee stated that the amount of play cannot be fixed—that it depends upon the size of the motor.

Mr. Reed does not believe in making his own babbitt metal. Most operators discussing the question use the "stick" method of determining babbitt temperature and seem to find it satisfactory.

Mr. Blakeslee said that he left most of the control repairs to the general maintenance men.

The advisability of piece-work methods in the repair shop received some discussion. A few operators are trying to standardize shop methods and put in piece-work practice.

Mr. Standing stated that 21 per cent of his armatures are spares and that he believed this amount was too high. He and Mr. Blakeslee both said that the amount of spares depends upon the condition of the mill and the character of the drive. A motor which, if it should fail, would tie up a whole mill or a vital section of it, naturally should have complete spare-part protection. With less important motors less protection is required.

Rolling Mill Adjustable-Speed Drives

By L. A. UMANSKY

Industrial Engineering Department, General Electric Company, Schenectady, New York

THERE ARE a good many reasons why most of the mills with a diversified line of products should have several rolling speeds. A uniform average speed may be a poor compromise: the output of lighter sections may be curtailed; they will be rolled at a lower temperature and the amount of power per ton of steel rolled will be appreciably higher; some small sections would be so cold in the finishing passes that the quality of the product would be impaired. Likewise, troubles may be expected with heavier sections; the compromise speed may be too high for the rolls to get a good hold on the metal when the steel enters the mill. It might happen that, by selecting a constant-speed drive for such mill, the extreme light and heavy sections could not be rolled on it at all and the work would have to be passed to other mills, if such are available.

It should be stated at the very beginning, that any electrical adjustable-speed drive, regardless of the speed-regulating system employed, costs appreciably more than a constant-speed drive. However, the primary purpose of any mill is to roll steel—the more of it the better. There is no use comparing costs of several systems of electric drive, without checking their effect on the mill output; the most economical drive is not the one that has the lowest cost, but the one that costs the least per ton of steel rolled. The cost of electrical equipment is only a part of the cost of the whole; one is truly wise who pays more for a part to save on the whole. In selecting a system for driving a mill the drive should be fitted to the mill and not the mill to a type of drive favored for reasons other than mill requirements.

[The body of the paper is devoted to a discussion of the mode of operation, characteristics, advantages and disadvantages, and the factors governing the selection of the following types of drive: two-speed drive; wound-rotor induction motor with secondary resistance; Scherbius system; Kraemer system; frequency converter system; brush-shifting, alternating-current motors; direct-current motors using field control; direct-current motors using voltage control; direct-current motors using a combination of field control and voltage control; and direct-current motors using a combination of field control and voltage control. Due to the length of this discussion it cannot be abstracted in the space available.]

While it is extremely difficult to set hard and fast rules for making the choice between the various systems of adjustable-speed drive, the

following conclusions, are believed to be generally true;

(1) An alternating-current drive has a better efficiency than a direct-current drive. The larger the mill tonnage is, the more valuable becomes each per cent gain in efficiency.

(2) Alternating-current, adjustable-speed drives are capable of correcting their power factor and bringing it close to unity. Direct-current drive with synchronous motor generators have leading power factors on the alternating-current line, and are capable of providing leading corrective kilovolt-amperes.

(3) When isolated mill drives are considered, the alternating-current drive will, in most cases, be found lower in the first cost than in the maintenance. The reliability is greater.

(4) With several drives driving the same mill, the direct-current proposition may have a lower first cost. Only a close analysis will show where the dividing line is.

(5) The increase of speed regulating range is more expensive with alternating-current drive than with direct current. A speed range of substantially more than 2 to 1 may be too expensive for alternating current.

(6) The larger the capacity of the drive is, all other things being equal, the more prominent become the advantages of the alternating-current drive. For very small capacities, like 300 to 400 hp., the cost per horsepower of the regulating equipment for an alternating-current motor becomes high.

If a choice is to be made between a Scherbius or Kraemer system the following factors should be noted:

(1) The Scherbius system can give a double-range operation; the main motor can run non-regulating and roll the majority of sections at the average speed.

(2) The efficiency and power factors of both systems are about the same.

(3) Either Scherbius or Kraemer can be built for constant horsepower or constant torque. On the same basis, the Scherbius system employs one less machine than the Kraemer system.

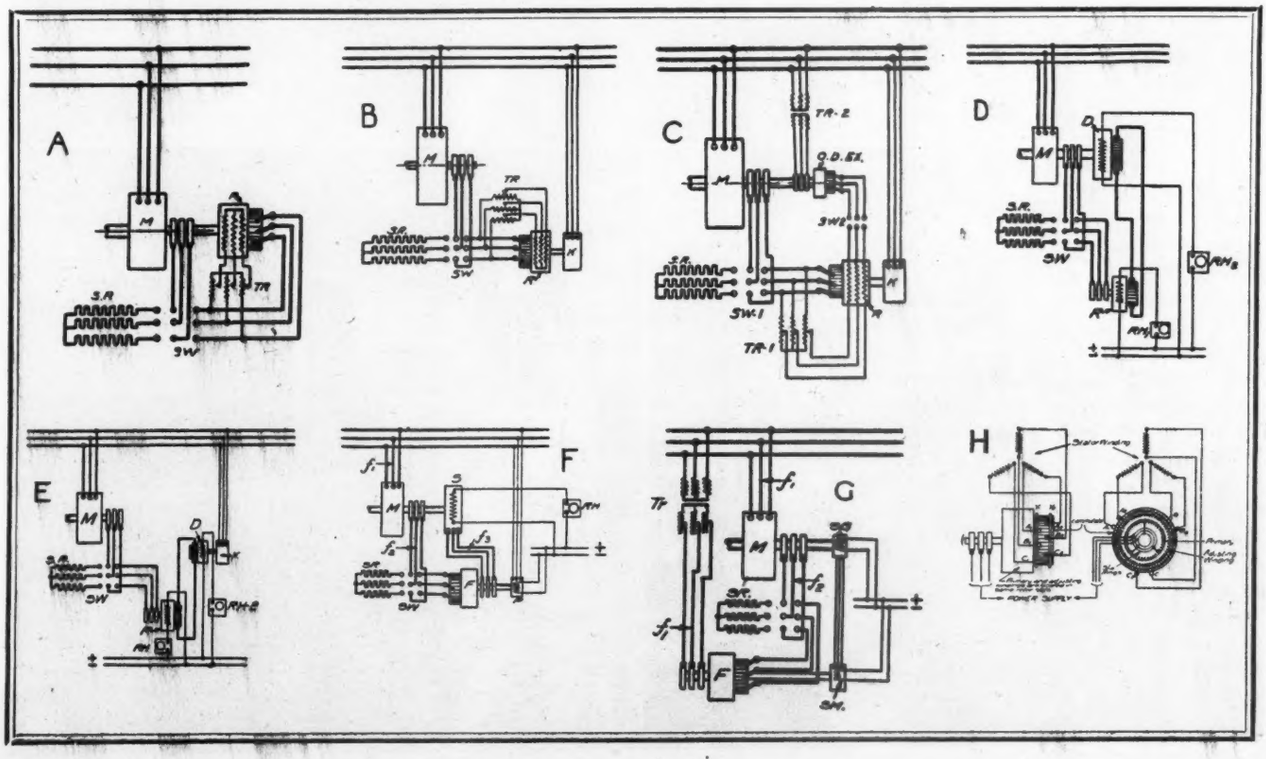
(4) The control of the Scherbius drive is somewhat more complicated. The control, however, consists of standard devices and is just as reliable as that of any constant-speed induction motor.

(5) The use of 60-cycle power as compared with 25-cycle lowers the cost of the Kraemer drive, but does not increase the cost of the Scherbius equipment. The speed regulation of the 60-cycle, double-range, Scherbius drive is limited to approximately 30 per cent above and below synchronism, that is, to a maximum speed range of 130 to 70 = 1.85 to 1.

Nowhere as in the question of adjustable-speed drive should engineering analysis be given a freer hand. It is far better to make a complete preliminary study of the subject, than to make a rash and possibly wrong decision and then pay for it in tons that might have been rolled.

Diagrams of the principal connections for eight forms of adjustable-speed drives.

In diagram **A** is shown the principal connections of a single-range Scherbius drive of the constant-horsepower type. *M* is the main induction motor, on the shaft of which is placed the regulating machine *R*. *Tr* is the field control transformer used for speed adjustment, *Sw* is the throwover switch to throw from the starting resistors *SR* to the regulating machine *R*. At **B** is shown the connections for a similar set of the constant-torque type. In this set the regulating machine *R* is not connected to the shaft of the main motor *M*, but is connected to the shaft of a squirrel-cage, induction motor *K*. At **C** the addition of the ohmic-drop exciter *ODEx* permits speed regulation not only below but also at and above synchronous speed of the main motor. This layout is known as a double-range, Scherbius drive. *TR-2* is the stepdown transformer for the ohmic-drop exciter. At **D** is shown an elementary diagram of connections for a constant-horsepower Kraemer drive. *M* is the main induction motor on the same shaft of which is a direct-current motor *D*. *R* is a rotary converter and RH_1 and RH_2 are field rheostats. *D* Diagram **E** is for a constant-torque. Kraemer drive. This set differs in that the motor *D* is taken from the shaft of the main motor *M* and connected to an induction motor *K*. Diagram **F** is for a constant-horsepower, frequency-converter drive. *M* is the main induction motor, *F* is the frequency changer, *S* is a synchronous motor and *P* is a small synchronous motor for driving the frequency changer at synchronous speed. Diagram **G** is for a constant-torque, frequency-converter drive. In this diagram *M* is the main induction motor, *F* is the frequency changer. *SG* is a small synchronous generator, *SM* is a small synchronous motor, *TR* is a transformer for transmitting the slip energy between the line and the frequency changer, and is used for speed adjustment. **H** is the elementary diagram of connections for a brush-shifting, polyphase, adjustable-speed motor.

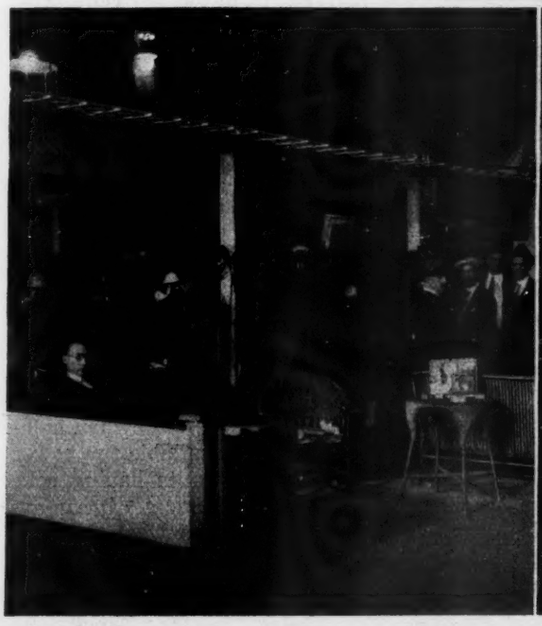


FASTS FLEXIBLE
The CUTTER ELECTRICAL & MFG. CO.
The CUTTER ELECTRICAL & MFG. CO.
J.A. JAQUES
MFD. MALOX

Steel Mill Equipment Show

At Pittsburgh Convention of Association of Iron and Steel Electrical Engineers

The million-dollar exposition of equipment for steel mills is shown from several different angles in the pictures on these two pages. More than one hundred companies displayed the latest developments in a wide variety of equipment used in the iron and steel industry.



Crane Hoist Travel Limit Devices

By WALTER GREENWOOD
Safety Engineer, Ohio Works, Carnegie Steel Co., Youngstown, Ohio.

FAILURE of regulating devices for control of electrical apparatus is the chief cause of mishaps that cause impairment of electrical equipment, and machinery operated by electrical equipment. Also, it is the cause for delay of operations, loss of production and injuries to persons while engaged in handling electrically-operated equipment. The list of devices that fail and produce disastrous results include automatic breakers of various kinds, switches, speed limits and travel limits.

The failure of hoist-limit devices is of such frequent occurrence that we are not surprised at the attitude of some whose preference is to rely entirely on operators to stop the hoist travel at the proper time instead of employing a limit device that is not entirely dependable.

It is a general belief that limit devices where installed, have very nearly made impossible mishaps that can occur from neglect of operators to apply the control equipment. It is known that limit devices, claimed by their makers to be faultless and infallible, do fail. In answer to the question, "Are they entirely dependable?" the common reply is "No." Replies made by some superintendents, where a large number of cranes are included under their management, is that failure of some one of the total number of limits employed does occur as often as once each week. These failures frequently are expensive; sometimes the expense is increased by delay of operation and loss of production. Loss of life from such mishaps is not an uncommon occurrence.

In discussing hoist limits with various persons, these points have been agreed upon: a hoist-limit device should be considered as only an auxiliary to manual control. The principle features of limits are interruption of current and the application of dynamic breaking; the addition of any other feature involves care and attention that means additional maintenance cost. If they do not automatically reset, the time consumed in resetting, if the method is purposely made inconvenient, will sometimes be a serious delay. This encourages operators to make the limit inoperative. If proper attention is not given to the method of installation and to maintenance their reliability is much affected.

In too many cases, the installation of a protective device is made by persons who in some particulars disregard instructions furnished by the maker of the device. This is done in some cases because the requirements are thought to be unnecessary and cost can be reduced; in other cases because they think they can see better methods.

Power in the Iron and Steel Industry

By BARTON R. SHOVER
Consulting Engineer, Pittsburgh, Pa.

SECOND only in importance to the supply of raw materials for making iron and steel is power, whether human or mechanical, and the tendency of man to shirk physical labor together with the growing demand for the product and the increasing cost of fuel, make the problem of mechanical power one of vital interest.

From data taken from the Statistical Report of the American Iron & Steel Institute and from findings of the Carnegie Institute, it is estimated that the steel industry consumes for power purposes only, more than 12,400,000 tons of coal per year for the average production and over 15,900,000 tons for maximum production; should all plants operate to capacity, nearly 21,400,000 tons would be required. In this connection a table was presented showing the number of power units and their rated horsepower for the plants consuming this coal.

From data collected by the Association of Iron & Steel Electrical Engineers for 1923, the ratio of the horsepower of prime movers driving electric generators to the horsepower of motors installed is 0.59 to 1. A study of data submitted by different companies developed the fact that the more completely the plant is electrified, the higher is the ratio between generator and motor capacity; in other words, the better is the load factor of the motor installation. Some of the older plants where motors were used for cranes, tables, etc., only, had a ratio that was as low as 1 to 7.

Practically all primary power generated in the steel plant comes either from steam or internal-combustion engines. While reciprocating engines still comprise the larger proportion of power units, the turbine is coming more and more into use. Although a great number of internal-combustion engines have been used, conditions have changed such that there is now a strong tendency in the other direction. Increase in speed, capacity and efficiency of the turbine, together with its lessening cost per horsepower, has swung the tendency towards it. Close inquiry shows the installation of only five gas-engine, generating units aggregating 21,140 kw. capacity, since 1918. This capacity compares with the 357,375 kw. of turbo-generators which have been installed during the same period and clearly shows which method of power generation is at present preferred.

Data from the last annual report of the Bureau of Census shows that while the increase in the total capacity of motors operated from plant power was 1,113,576 hp., or 140 per cent, the increase in capacity of motors operated from purchased power was 727,475 hp., or 949 per cent. The increase in capacity of motors operated from purchased power being so nearly equal to that of motors operated from plant power shows that purchased power must be considered as part of the power system and that there is an increasing tendency to depend more and more on electric power generated outside the works, principally by public-service companies.

Although a large quantity of coal is consumed, a large amount of by-product fuel and waste heat are used for power generation. It can be shown that there is more than sufficient waste heat available for power requirements in plants having coke ovens and blast furnaces. On an average twice as much waste heat as should be required, is used for power purposes, to say nothing of half

again as much coal in addition, or a total of five times the calculated requirements. This offers a fertile field for the development of future economy.

Coke ovens and blast furnaces operate continuously, whereas steel works and rolling mills are normally idle over the week end; consequently, about one-seventh of the waste heat from the principal sources is given off when there is no use for it by its largest consumers. This condition can be met by interchanging electric power with the local public-service company. There are at least three places where this arrangement is in force and two others where negotiations toward this end are now in progress.

Power is applied directly or through electric energy, compressed air, or hydraulic pressure, but the amount used by the last two is so small a percentage of the total that it can be neglected. Because of its lack of overload capacity and inability to adapt itself to sudden changes in load, the internal-combustion engine is not suitable for driving roll trains or other apparatus of this character, but is well adapted for driving reciprocating, blast-furnace blowers. Due to lower first cost and convenience of operation, the turbo-blower has of late years made considerable headway. While it can show advantages in every respect over the reciprocating steam engine for blowing blast furnaces, the gas engine excels it in thermal efficiency. In fact, there is still a question, in spite of the higher first cost and operating expense, as to which of the two types of blowing units will show the better returns on the investment required.

In 1914, a turbine was direct connected to a roll train and although this outfit is still operating, it has never been duplicated; consequently, it can be assumed that the results of such drive are not satisfactory.

It is not within the scope of this paper to argue the merits of the different kinds of power units for main roll drive, but the tendency toward the use of electric motors as opposed to steam engines is too marked to allow passing without notice. Common practice is a good argument. In 1923, one electrical manufacturing company furnished nine motors aggregating 27,650 hp., to replace existing steam engines driving roll trains. Two other electrical companies report having furnished a total of forty-seven motors aggregating 103,565 hp. for this purpose. Against this showing not a single motor driving roll trains has been replaced by any other kind of power.

From the data, estimates and general history of the art as outlined above, the following is deduced as the present and probable future tendency of power generation and application in the iron and steel industry:

(1) The electrification of all power-driven apparatus except blast-furnace blowers.

(2) Substitution of turbo-blowers, or possibly gas engines for reciprocating-type, steam blowing engines.

(3) Purchase of power requirements by plants which have no waste heat available.

(4) Complete economical utilization of waste heat by means of turbo-generators for electric-power generation, except where this heat can be used to better advantage for "process" or has a market value greater than its coal equivalent.

(5) Interchange of electric power between plants of public-service companies and plants generating power from waste heat.

Report of Electric Furnace Committee

By GEORGE H. SCHAEFFER, Chairman
Electrical Engineer, Carpenter Steel Company, Reading, Pa.

THE question as to the effect on the steel of nitrogen generated by the electric arc of the furnace while melting down at a high voltage has been an open one. In the crucible, open hearth, Bessemer or electric furnace process, there is ever present the nitrogen content in the atmosphere, and an equal opportunity for chemical combination. From all available information we feel confident that within the limits of melting now used commercially, for example up to 210 volts, the electric arc does not cause a chemical combination of nitrogen with the steel bath. We are supported in this contention by the following information furnished by the Bureau of Standards:

"Electric steels normally contain from 0.002 to 0.005 per cent nitrogen. Open hearth steels contain nitrogen in about the same range—while the Bessemer steels normally carry from 0.010 to 0.015 per cent of nitrogen."

Serious consideration is now being given to high frequency induction furnaces on a comparatively large scale for the production of high-grade alloys for special purposes and for refining precious metals, although there have been no commercial installations.

Inasmuch as the previous reports dealt mostly with electric melting, the board of directors asked that we devote most of our time to the medium- and low-temperature equipment. With this idea in view, we have limited the subject of electric melting furnaces to detailing the improvements to furnaces, furnace control and furnace operation that have taken place since the last electric furnace report.

Electric Melting Furnaces

By J. A. SEEDE
Electrical Engineer, General Electric Co., Schenectady, N Y.

THAT any change in electric furnace practice is worth consideration is indicated by the 1923 electric furnace production of steel castings totaling 235,958 tons, or 50 per cent more than the best previous year, 1920, and the electric furnace production of alloy steel castings amounting to 29,054 tons or 64 per cent higher than the best previous year, 1922.

The most recent change has been in using so-called electrode economizers and the Soderberg electrode.

The electrode economizer is a device that fits closely about the electrode where it emerges from the roof, keeping the air from it and cooling it without oxidation.

The Soderberg or self-baking electrode will, undoubtedly, continue to be a source of discussion for some time to come. These electrodes have become firmly established in smelting furnaces, and are being successfully used in steel melting furnaces.

The productive capacity of a furnace unit may be increased by short-

ening the time to produce a heat and decreasing the time between heats. Electric heating is used to best advantage when preliminary heating has been done with cheaper sources of heat, but it is doubtful if all the possible advantages have been realized. Preheating by oil or gas in the Loshbough combined charging bucket and preheater, in combination with an opening roof furnace is interesting. That such a method is profitable is indicated by the energy consumption dropping in several installations from approximately 600-kw.-hr. per ton to less than 400 kw.-hr.

The need for increased production has led to a gradual increase in input to arc furnaces from 225 kva. for a 1-ton furnace to 600 kva and higher at the present time.

With the original equipment, it was a simple matter to obtain fair operation with one secondary voltage, about 60 volts across the arc, but with increased capacities, a higher voltage for melting and lower voltage for refining seem to offer advantages over methods previously used.

Reducing time between heats is a mechanical problem which involves getting the melted metal into ladles and charging the furnace with the minimum possible delay. Three solutions have been offered for this problem: charging machines, opening roof furnace and multiple melting furnace. The latter involves the use of one set of electrodes, transformers and control panels with two furnace shells mounted on a turn table. This makes a very compact arrangement, and in place of the 20 to 30-min. intervals between heats, 4-min. intervals are common.

Brief reference to the largest induction furnace now operating in this country may be of value. For several years a 2-ton furnace has been operating at the Pittsfield works of the General Electric Co., with entire success. The linings now average 500 heats and individual linings occasionally go 30 per cent above this figure.

Low-Temperature Applications

By E. A. HURME

Manager, Steel Mill Section, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

THE field of industrial heating can be divided into two classes: medium- and low-temperature applications. Medium-temperature units are ordinarily classed as furnaces and operate from 1,000 deg. F. to 2,000 deg. F. Low-temperature units are classed as ovens and operate at temperatures below 1,000 deg. F.

One of the most successful applications of hearth-type industrial furnaces is in treating tool steel. Dies used in forming small parts by the die-casting process are subject to very high stresses and require special heat treatment.

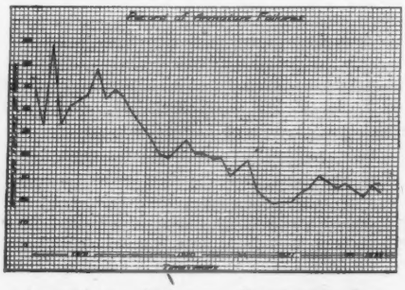
For this exacting work the Sanitary Tube & Stopper Company have adopted the electric furnace and find that they get better tops, save effort in heat treating dies and actually save $100.00 on each set hardened.

With the electrical equipment they are getting about one and one-half million tops from each set of dies. With the best gas-fired equipment, they could not expect to get half as many pieces and of the tops produced there would be many more poor ones.

Large industrial electric furnaces are used for a wide variety of purposes, the most important in iron and steel plants being the annealing of large castings, the annealing of sheets for stamping, hardening and tempering wire and steel springs, and hardening of steel parts.

A car-type annealing furnace 4 ft. wide, 6 ft. high and 10 ft. long is installed in the plant of the Keokuk Steel Castings Co. The heating elements in the walls and roof are covered with baffle plates.

The Transcona shops of the Canadian National Railways installed in 1923 a car-bottom-type electric furnace for annealing side rods, driving gear and coupler pockets of locomotives and cars.



Armature failures decreased by dipping and baking rewound armatures.

The curve shows how the armature failures decreased on an electric-railway installation after the dipping and baking of rewound armatures was adopted in 1919.

The average charge treated is 5 tons and the average weight of the pieces is over 150 lb. The production of the furnace is 8.34 lb. per kw.-hr. Including the cost of handling, the total cost is approximately $3.00 per ton.

The French Manufacturing Co., Waterbury, Conn., recently replaced a wood-fired, muffle-type annealing furnace with a 330-kw. electric furnace for annealing seamless brass tubing.

The power consumption averages 110 kw.-hr. per ton of brass annealed, or a production of 18.2 lb. of brass per kw.-hr. The cost of electric power exceeds the previous cost of fuel by only 7½ per cent, but other savings bring the cost of operation below that of the old fuel-fired furnaces.

Continuous electric furnaces are used by the Stewart Hartshorn Co., for annealing and hardening steel wire used for making small springs. The cost of operation shows a saving of over 32 cents per 100 lb. in favor of the electric furnace, as compared with the gas-heated furnace.

Heating units operating at temperatures below 1,000 deg. F., are classed as ovens. This class of heating element is used to advantage in iron and steel plants in such processes as the following: Drawing the temper of tool steel hardened in a medium-temperature furnace; baking sand cores; baking motor armatures, enameling. Under special applications are the following: Electric steam boilers, sheet mill roll heaters, heating of metal pattern plates, air heaters.

In the electric railway field the baking of rewound motor armatures has resulted in a materially increased life of the armatures in service. An increase of 75 per cent in the average life is not uncommon. The accompanying curve shows how the armature failures decreased on a typical electric railway installation after the dipping and baking of rewound armatures was adopted in 1919.

The similarity of mill- and crane-type motors to railway motors and the service to which they are subjected would indicate that the adoption of the practice in steel mill repair shops would be amply justified. A furnace capable of handling eight armatures per bake can be installed at an approximate cost of $1,200 to $1,400. Baking the armatures seals up the insulation which may have

been cracked during winding, excludes the moisture and prevents deterioration of the insulation. Few steel plants have tried the baking of rewound armatures.

The low-temperature oven has proven the ideal method for baking enamel on steel parts such as automobile fenders and batteries. With the electric oven a better finish is obtained, due to the more uniform application of the heat and there is less danger of explosion.

Electric preheating of the finishing rolls of sheet and tin mills is a new development in low-temperature electric heating. The marked benefits afforded and a pronounced superiority over any previous heating methods are rapidly establishing this as a distinct improvement in the art of rolling sheets.

Medium-Temperature Installations

By C. F. CONE
Engineer, George J. Hagen Company, Pittsburgh, Pa.

THE Fowler and Union Horse Nail Company, Buffalo, N. Y., decided to erect a new plant in Buffalo and felt that the installation of an electric furnace for the annealing of wire would eliminate many of their troubles in the manufacture of horseshoe nails.

The furnace purchased is known as the regenerative, car-type furnace. There are three chambers: heating, cooling and preheating. The cooling chamber is in tandem with the heating chamber with a common door between. The preheating chamber is at the side of the cooling chamber with the common wall removed to allow free interchange of heat from the hot to the cold charge.

The charge is ⅜-in. diameter wire in coils weighing approximately 250 lb. per coil. The coils are stacked and the charge per car is approximately 7,500 lb. The furnace delivers 3½ tons every three hours. The heating chamber temperature is held at 1360 deg. F. The total connected load is 180 kw. at 440 volts, three phase, 25 cycles.

The temperature of the heating chamber is automatically controlled by a potentiometer type of recording controller.

This furnace has been operating practically every working day since November, 1920, and has turned out several thousand tons of annealed wire without a single rejection or reheating.

Gray & Davis, Inc., Amesbury, Mass., do deep drawing of ¼-in. and 5/16-in stock. They draw in four operations and require two anneals. A pusher-type oil furnace was formerly used. Rejections were large, pickling costs were high and die life was short, due to excessive scale.

A counter-flow, regenerative car-type electric furnace was installed. It has six chambers, with two rows of cars moving in opposite directions. At each end is a preheating and cooling chamber with the common wall removed, thus permitting the transfer of heat from the hot to the cold charge.

The heating elements consist of heavy nickel-chromium ribbon suspended from the side walls on special hangers. Each heating chamber has a connected load of 110 kw. for operation on 220 volts, three phase, 60 cycles.

The furnace operates at 1,450 deg. F. and will handle 2,500 lb. per hour. On a 24-hr. cycle, the economy is 145 kw.-hr. per ton annealed.

The Canadian Allis-Chalmers Company, Toronto, Canada, desired a furnace to anneal transformer laminations, and felt that the electric furnace would give a lower unit cost than a fuel-fired furnace.

The furnace purchased was the double-end car type. The total connected load is 210 kw. for operation on 440 volts, three phase, 25 cycles. The average charge is 6,213 tons. Power is put on at 6 p. m. and the charge soaked all night at 1,600 deg. F. In the morning the hot car is removed and a cold car put into the furnace. The economy is 340 kw.-hr. per net ton annealed.

One of the most difficult problems of the Nash Motor Co., is the heat treating of automobile parts. This operation was formerly carried on unsatisfactorily in box-type, fuel-fired furnaces.

The parts to be heated vary from a small spring clip to a large front axle. The rotary-type furnace was finally selected. The rotating table revolves on rollers. The total connected load is 323 kw. for operation on 440 volts, three phase, 60 cycles. When operating on hardening, the furnace heats 3,000 lb. per hour and the economy is 170 kw.-hr. per ton at 1525 deg. F.

Another automobile company selected a rotary-type furnace for carburizing. The heating elements consist of heavy nickel-chromium ribbon suspended from the side walls. The chamber is divided into five zones, although there are only three control instruments. Three temperature zones are established which may be controlled independently of each other. Two furnaces were installed and each has a total connected load of 500 kw. for operation on 220 volts, three phase, 60 cycles.

The time cycle in the electric furnace is 12 hr., compared to 15 hr. in the oil-fired furnace. The economy is 200 kw.-hr. per gross ton. This actually gives a lower fuel cost than was obtained from twenty-five oil-fired furnaces in the same department. The saving in fuel and labor represents a return on the investment for the two electric furnaces of 81.7 per cent a year.

The Royal Typewriter Company had been having difficulty with the excessive wear on typewriter parts and finally selected a box-type electric furnace for treating these.

This furnace is 4 ft. 10 in. long, 3 ft. wide and 2 ft. high inside. The total connected load is 60 kw. at 220 volts, two phase, 60 cycles.

The operating temperature is 1,650 deg. F. and the average gross charge is 1,100 lb. The heating time is 5 hr. and the economy is 360 kw.-hr. per gross ton.

More box-type electric furnaces have been installed than any other type. The sizes vary from the small laboratory furnace to the large size working on a tonnage basis. One box-type furnace operating in the heat-treating room of a large tube mill is used for hardening dies. Since this furnace has been in operation, it is evident that they will obtain an increased die life of 33 per cent at least.

The electric furnace has met with its greatest success in the vitreous enameling industry. The electric furnace atmosphere is slightly oxidizing, which is ideal for this kind of work. There are no fumes or dirt which will discolor the ware. The temperature distribution is even so that all parts receive the same burning.

A number of furnaces, consisting of a main or upper burning chamber with an auxiliary or lower burning chamber, have been installed.

Main Points in the Discussion at Pittsburgh Convention

ALL those taking part in the discussion of the paper on "Adjustable Speed Drives for Rolling Mills" agreed that L. A. Umansky had written a very practical and comprehensive paper that added much to existing engineering literature on the subject. F. R. Burt pointed out that reliability must not be sacrificed for over-all efficiency when making a drive selection. He further stated that the speed of rolling is a matter of judgment and skill on the part of the operators, and as such cannot always be estimated as closely as might be thought. After an installation has been completed, operating conditions often change to such an extent that the original calculations do not hold true. F. B. Crosby said that it pays to spend money at the time of installation to make provision for rolling a variety of products, for after a mill has been installed it often is required to roll a product quite different from what was originally intended. He emphasized the necessity of considering all factors when making a drive selection for an adjustable-speed mill. In closing the discussion Mr. Umansky emphatically recommended that alternating-current drives should be used whenever possible and direct-current drives only when compelled to by special conditions, owing to the better over-all efficiency of the alternating-current drive.

Electric Melting Furnaces.—In the discussion of the papers on "Electric Furnace Installation" by Roy S. Sawdey, "Report of Electric Furnace Committee for 1924" by George H. Schaeffer, Chairman, and "Electric Melting Furnaces" by J. A. Seede, emphasis was placed on the reduction in melting time and increase in capacity obtained through the use of furnace improvements, including automatic control, Soderberg self-baking electrodes and other electrical equipment. Dr. Sem, who is visiting from Norway, discussed the operation and use of the Soderberg electrode. He said that the first self-baking electrode installation was made over five years ago and during that time some 850 ft. of electrode had been consumed without an electrode failure. In this connection he said that the installation has resulted in a 30 per cent saving in electrode cost as compared to the European carbon electrodes formerly used and a saving of 7½ per cent in power consumption, due to more regular furnace operation. He pointed out that one of the greatest advantages of this electrode is that it may be made in any shape or size, thus making the electrode fit the furnace and not cause the furnace to be designed for the electrode.

Some question was raised in regard to the load factors obtainable with multiple and single furnaces. One operator stated that he believed the load factors of 70 per cent for the former and 45 per cent for the single furnaces were too high.

Medium and Low Temperature Applications.—In discussing this paper by E. A. Hurme and "Medium Temperature Furnace Installation," by C. F. Cone, Gordon Fox of Freyn, Brassert & Co., stated that the first complete installation of electric roll heaters has just been finished. Heretofore mills have only put in a few heaters, but this installation at a large sheet mill in Ohio consists of one roll heater for each of the fourteen stands in the mill. A very convenient method of handling and storing the heaters in racks has been developed and is in use in this plant. He stated that through the use of these heaters it was possible to start rolling good quality sheets at the beginning of the first turn and that the tonnage on the first turn was comparable to that of the other turns, which is twice as much as obtained before.

The value of a demand-limiting device for use with furnaces was mentioned and described. It is attached to demand meters to give warning of or prevent an unusual and infrequent demand that would establish an excessive power rate. The author mentioned that the device makes it possible to control the peaks of furnace loads and save many times the installation cost in a single year.

A new elevated type of furnace having no door was also mentioned. It was stated that the use of this construction results in a furnace having a burned-out atmosphere with no scale forming or oxidizing action.

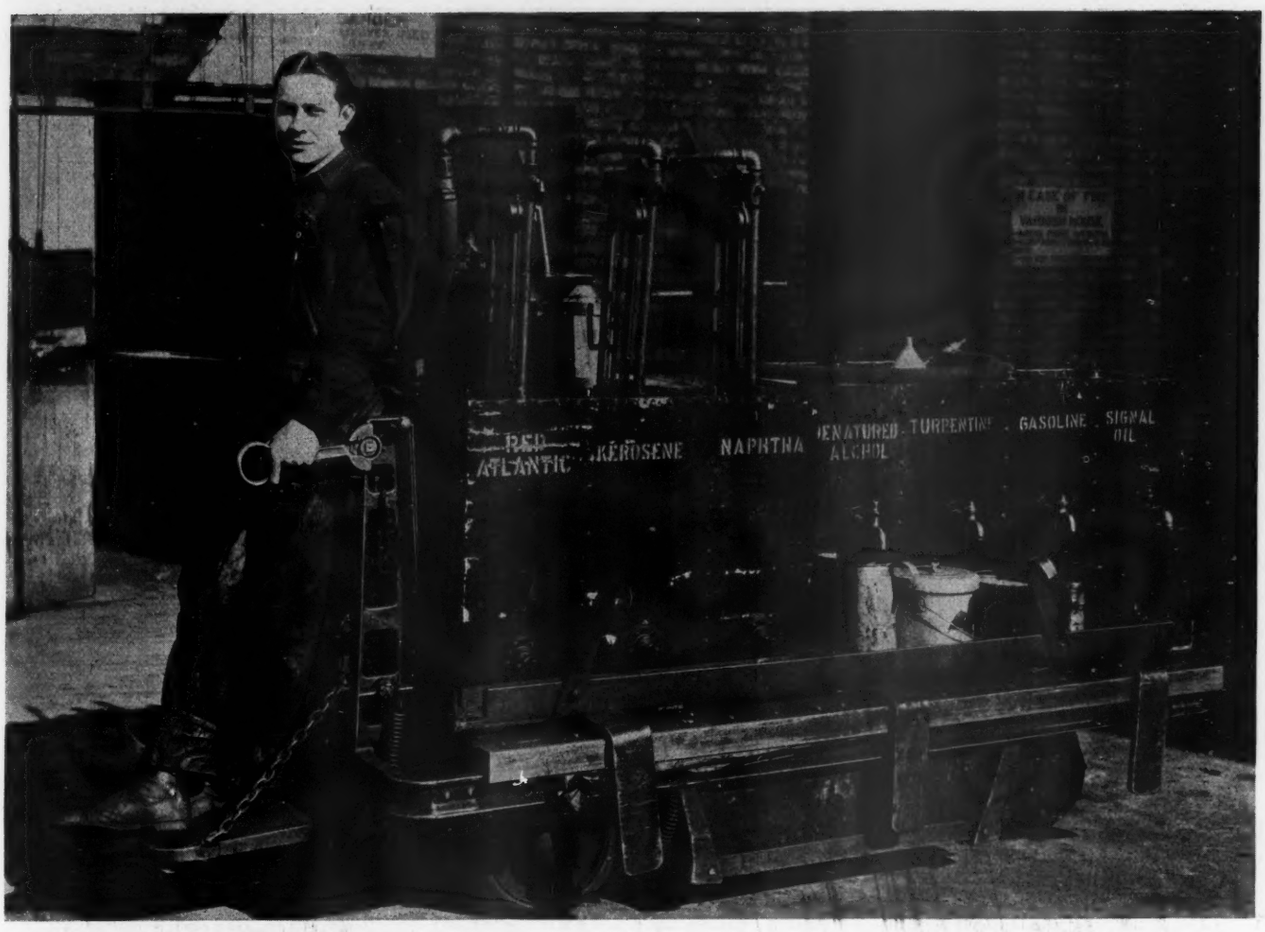
Crane Hoist Travel Limit Devices.—In discussing this paper, which was presented by Walter Greenwood, Safety Engineer of the Carnegie Steel Co., S. S. Wales, Electrical Engineer of the Carnegie Steel Co. spoke of the difficulty of preventing crane operators from "by-passing" or shunting the contacts of the limit switch so as to make it inoperative. He said that the elimination of this practice was not only a matter of education of the operators but also a factor which should be considered in the design of the limit stop. He criticised the use of two heavy weights on some of the limit devices, stating that there is a danger of the weights falling on someone below, and also of fouling the hoisting cable.

Mr. Wales stated that many of the limit devices are of too light construction and that trouble is experienced with burning of the contacts. On some of his cranes the upper travel clearance is so small that the limit stop is required to function on practically every shift. On these applications he finds that the contacts are too small.

Mr. Richardson spoke of having trouble with ropes and weights. He believes that most of the present day limit stops are too large; there is not room to mount them on the crane unless the operating ropes are run through several sheaves. He condemned this practice. He makes many of his own limit devices and prefers a reverse-current switch to one having a dynamic stop.

R. S. Shoemaker of the American Rolling Mill Co. disagreed with him on the size of limit switches. Mr. Shoemaker stated that he believes the limit stop should be large, expensive and the best that can be obtained. He has tried the practice of removing the stops from the hoist and making the operator responsible for accidents caused by running the blocks against the drum. In case the operator had two accidents he was automatically discharged. This practice was unsuccessful for it did not eliminate the accidents and was the cause of losing good men.

Ball and Roller Bearing Standardization.—At a business meeting of the association it was proposed that the manufacturers' 300 series of ball and roller bearings be adopted as standard by the Electric Power Club. This matter is now being considered by the latter organization.



This electric truck makes daily deliveries of oils and greases to twenty-two tool rooms. It carries two tanks with compartments of suitable size and furnishes everything carried in the oil house and required by the shop, including oils, naphtha, gasoline, turpentine, greases, and white and red lead.

How $6,929.06 Has Been Saved in the

Purchase, Storage and Distribution of Lubricants

During One Year by a Bulk Storage and Delivery System for the Manufacturing Departments of the Allis-Chalmers Manufacturing Company

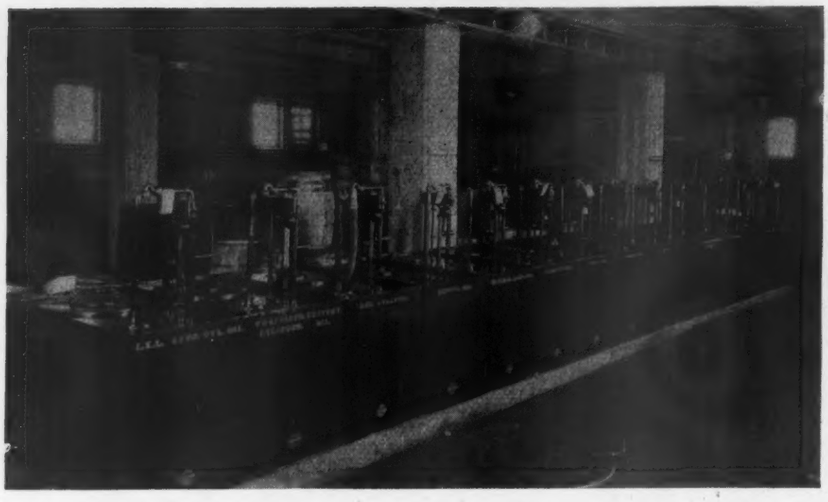
By HENRY FREEMAN

Superintendent Forge Shop, Allis-Chalmers Mfg. Company, Milwaukee, Wis.

IN THE summer of 1922, several committees were appointed by our assistant general works manager, to economize in supplies used generally throughout the shops. Success was so marked in the first drive on company tools and tool steel that other supplies were immediately made the subject of similar investigation. A committee, composed of Jas. Larsen, *Superintendent of Shops* 1, 2 and 3; Chas. E. Schnader, *Chief Power Plant Engineer;* R. S. MacPherran, *Chief Chemist,* and Henry Freeman, *Superintendent of the Forge Shop,* was appointed to study and improve the purchase, storage and distribution of oils, paints, and greases. At present West Allis Works boasts a fine system and the following is an account of the committee work leading up to it.

The survey of prevailing conditions revealed much opportunity for improvement. In the main oil house, where all stock is kept as it comes to the plant, there was evidence of wasteful, inefficient equipment. Of twenty-three service barrels, supported on a long rack, some were of wood, some of steel, some with faucets, some with valves and other fittings, and all of them were leaking more or less, all being wasteful. The same condition existed in the twenty-two tool rooms which carry the oil supply in the various departments in the works; every style of can, tank, barrel and drum that could be picked up was being used for storing and handling. In only one shop did we find them handling oil in an efficient way.

White lead was carried only in 100-lb. cans and in some departments this was six months' to two years' supply. Most tool rooms had an oversupply of cup grease in bad and dirty condition and in some cases unfit for use. It was very soon apparent that we needed a thorough housecleaning and that we must get fresh oil and clean grease to all users daily. This afterwards became the slogan of the committee, "Fresh Oil and Clean Grease Daily."



These fifteen 120-gal. tanks are located in the main oil house and are equipped with 1-gal. oil pumps. and hose connections. They take care of the heavy shop requirements.

After getting a line on the way these materials were being handled in our works, we began to investigate what other people were doing in this line. We visited plants having oil tank installations, some large, some small, but we found none very complete.

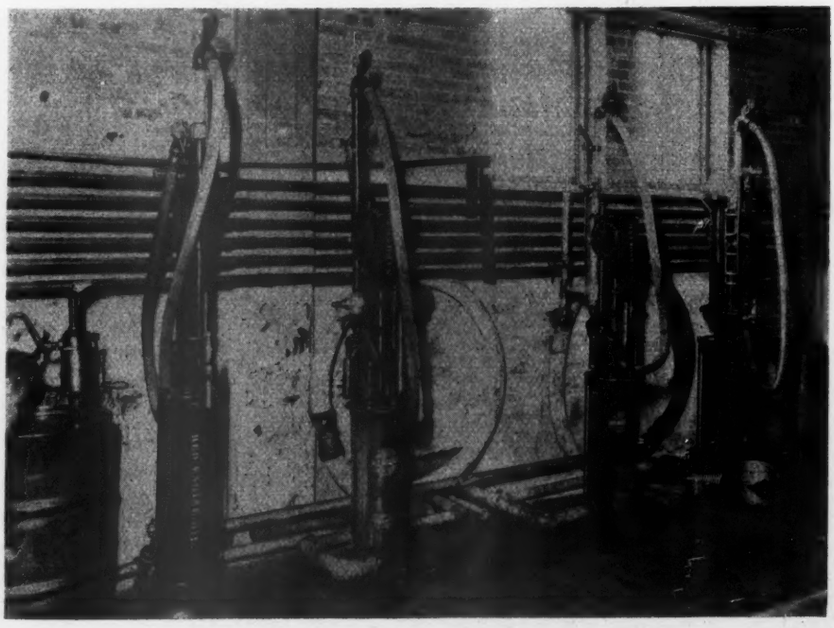
Then we visited shops that made large tanks and shops that made small tanks, and got all the information possible from them. We visited the supply houses and looked over the stocks of plain cans and pump cans of every kind and other supplies that might help us. We have corresponded with all the people who furnish oil installations and got their recommendations and prices. We visited all the large oil companies in the city and looked over their method of handling oil. Mr. MacPherran corresponded with the engineers of the large oil companies for information regarding the best way to handle the various varnish oils, and other volatile oils. No recommendations have been made until all information possible had been obtained and the practicability of the proposed plan carefully considered from every standpoint.

Saving in Core Oil Equals $404.25 in One Year

In the foundry, core oil was being bought by the carload in drums; these drums were unloaded by hand, stored in the gallery taking up valuable space, then man handled to the mixing room and lifted to a bench and tapped, taken off by hand when empty and later loaded on cars for return. To take care of this situation there has been installed underground a 12,000-gal. tank and purchase is now made by tank car lots. There has been installed in the mixing room a 5-gal. Milwaukee pump so that the men pump the oil as required and all drip returns to tank. This has resulted in a saving of 7.5 cents per gallon on tank car purchase, over purchase in drums. Our consumption in 1923 was 5,390 gallons, which made a total saving of $404.25.

Pump Equipment Installed in the Oil House

In the oil house there has been installed a Milwaukee battery system of fifteen 120-gal. tanks equipped with 1-gal. pumps and hose connections. These take care of the heavy shop requirements. There have also been supplied rotary barrel pumps so that they can pump direct from the original barrel or drum, the drip returning to barrel, instead of to an outside pan. They have been furnished with Marvel pumps for pumping and measuring grease from the barrel. This will take care of the heavy oils and light grease. There have been installed underground the following tanks: one 10,000-gal. tank for naphtha, one 10,000-gal. tank for lubricating oil, one 10,000-gal. tank for paraffine, and one 2,000-gal. tank for gasoline. These tanks are each connected to 5-gal. Milwaukee service pumps in the oil house. The naphtha pump is arranged to deliver this material to tanks on the second floor when required.



These 5-gal. service pumps are connected to the underground oil storage tanks.

Standard Oil and Grease Cans for 22 Tool Rooms

Our twenty-two distributing tool rooms have been equipped with uniform pump cans of 3-, 5- and 10-gal. capacity. These cans have a drain back for the spill and drip and a standard-size grease pail with cover. All old grease cans, pails and other containers were collected and destroyed and in their place the tool rooms have been furnished with a standard 2-lb. can with cover. Limiting the men to this size can has compelled them to go to the tool room more frequently and get clean grease as needed.

They have also been supplied with a standard 2-lb. or 1-qt. oil can with cover soldered on, with a small hole in the top for a brush; this to be used on drill presses, where oil is required

for drilling and tapping, also a standard can with hinged cover for white lead. These are given out on check to the workmen as required. All these cans are carried in stores to make replacements and keep the standard uniform in all departments of the works.

All unnecessary oil and grease cans in the shop cupboards and other odd corners have been eliminated and anyone needing oil, grease or white lead is required to go to the tool room, assuring a supply of fresh oil and clean grease.

Daily Delivery of Oil and Grease by Electric Truck

There has been installed a daily delivery system by electric truck. This truck has been especially designed and built to meet the requirements. It has two Milwaukee tanks of five and three compartments respectively of 10-, 15- and 20-gal. capacity and carries everything in the way of oils, naphtha, gasoline, turpentine, greases, white lead and red lead; in fact some of everything that is carried in the oil house and required by the shop. This truck makes a daily trip to each of the twenty-two distributing tool rooms in the works and delivers whatever they may require and takes the tool room tender's receipt for the supplies. The driver makes the round trip in two to two and one-half hours. The truck returns to the oil house where supplies are replenished and everything is made ready for the next day's run.

It is interesting to make a round trip with the oil truck and note the business-like way and the dispatch with which supplies are ordered and delivered. Wherever possible, carrying the oil from the truck tank to tool room tank has been eliminated and the tool room tanks are so arranged that oil can be pumped directly from the truck tanks. For the special supplies or those used only occasionally and in small quantities delivery is made in their own cans as required. This part of the service has given very general satisfaction throughout the departments.

Previous to this time there were on the average fifty-five men from all departments calling at the oil house for supplies every day. Since the system of delivery by truck has been installed this has been reduced to five or less per day, a reduction of fifty visits per day. A conservative average of each man's time per visit would be about 15 min.; then $50 \times \frac{1}{4}$ hour $= 12\frac{1}{2}$ hours, less $2\frac{1}{2}$ hours for delivery time by truck leaves a net of 10 hours daily, 300 times (for working days) at 45 cents per hour equals more than $1,350.00 per year. This is a very important saving together with the fact that we are delivering "fresh oil and clean grease daily."

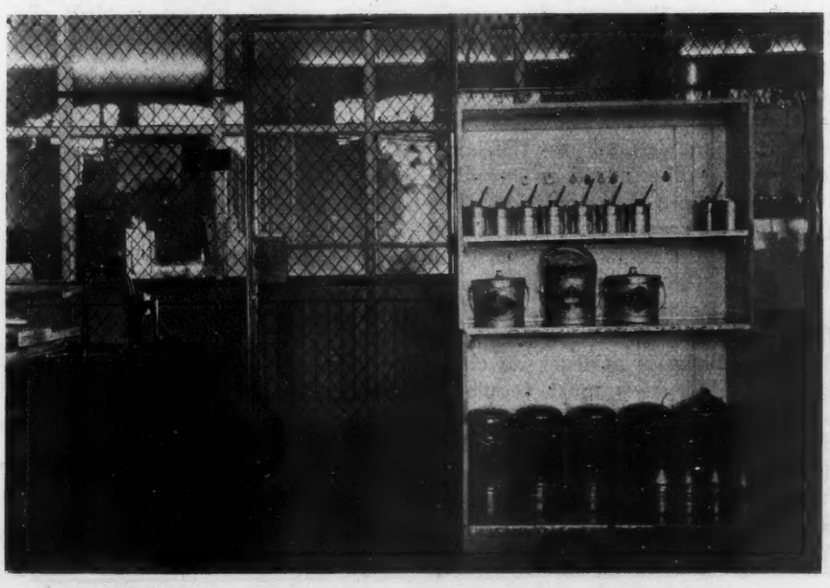
Being able to go into the market for tank car lots of lubricating oil, naphtha, kerosene, paraffine, gasoline and core oil, a considerable saving has been effected over purchase by barrel or drum. A summary of this saving over a period of one year would be about as shown in the above tabulation which also gives the amounts used and prices paid for the different materials.

Comparative Prices of Oils and Gasoline and Savings Under New Plan

Material	Used in 1923	Barrel per Gal.	Tank per Gal.	Saving per Gal.	Total Saving
Kerosene	4,605	.113	.073	.04	$ 184.20
Gasoline	25,418	.167	.127	.04	1,116.72
Naphtha	35,439	.202	.148	.054	1,913.70
Paraffine Oil	10,671	.146	.073	.073	778.98
Red Engine Oil	14,611	.199	.125	.074	1,081.21
Core Oil	5,390	Differential		.075	404.25
					$5,579.06
Eliminating visits to oil house					1,350.00
Total direct saving for one year					$6,929.06

Standard oil containers provided for tool rooms.

Twenty-two distributing tool rooms have been equipped with pump cans of 3-, 5- and 10-gal. capacity. They are also provided with standard 2-lb. or 1-qt. oil cans with a small hole in the top for a brush, for use in drilling and tapping operations, and standard 1-qt. cans for white lead. Grease is furnished in standard 2-lb. cans with cover, to keep it fresh and clean.



Difference Between Total Expense and Saving for One Year

Then there is the indirect saving by elimination of the daily handling of barrels, the loss by side- and corner-cling to the barrel is also eliminated; this is figured by oil engineers at 2 per cent. The cost of installing the five underground tanks at the oil house and foundry with pumps and hose connections complete, exclusive of the tanks, amounted to $4,164.48.

Cost of large underground tanks, installation and equipment at oil house and foundry	$4,164.48
Cost of equipment and installation of truck tanks, pump tanks at oil house and tool rooms complete	3,226.00
	$7,390.48
Total direct saving for one year	6,929.06
Difference between total expense and saving for one year	$ 461.42

THIS IS THE second article on Industrial Safety by Mr. Donald in which he emphasizes the importance of the centralization of the work in the following statement: "If the Maintenance Engineering Department is not the center of accident control, it is at least its chief ally, for all upkeep must regularly be referred to it. One advantage of placing accident prevention in this department is the avoidance of irritation which frequently results when workers or executives of one department presume to examine and criticize conditions in another. Another advantage is that the primary requisite for a reduced cost of accidents is a well-kept plant."

Some Practical Pointers on

Directing Attention in Safety Work

With Reference to Standardized Safeguards and Some of the Details of Making Inspections

By H. W. DONALD

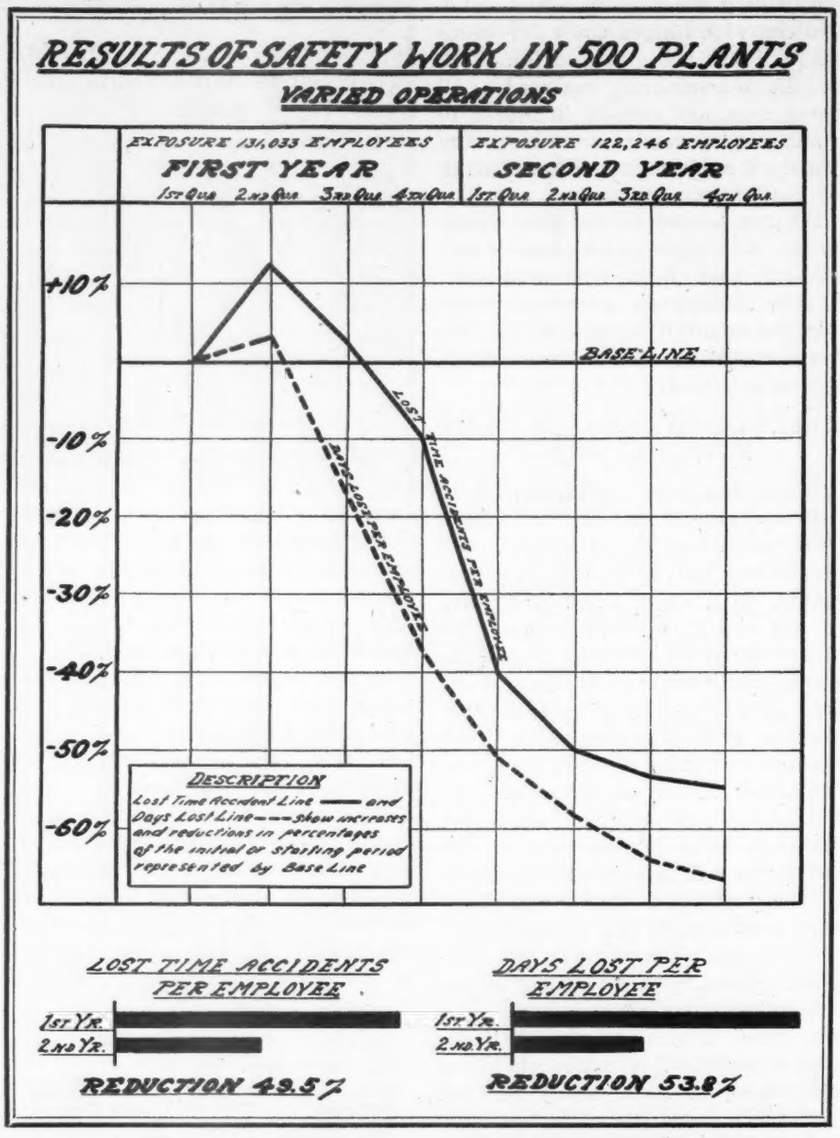
District Manager of Engineering, American Mutual Liability Insurance Company, Boston, Mass.

HEALTH AND SAFETY of the employees in the industrial plant, large or small, calls for as intelligent and as systematic attention as the upkeep of machines, for there has been a steady advance and broadening of the standards of personal health and safety with each advance in industrial development. With accident prevention in view a human interest is added to the daily grind of fixing up an inanimate plant and machines. Human safety when once considered and understood stimulates the interest of all concerned and in arising to the needs of their fellow-workers all are watchful of slack or wear in plant and equipment.

In the larger industries, a division of the repair work is necessary. With a systematic plan of reporting, housekeeping features are carefully inspected and accurately controlled. Sanitation and cleaning, for instance, are frequently the work of separate departments, with considerable economy and increased efficiency, for with the old system of sanitation within the departments the areas in between were a "no man's land" for the janitor's crew. The nurse or hospital staff inspects and reports on this question and keeps an accurate check of sickness and industrial disease in addition to the record of accidents.

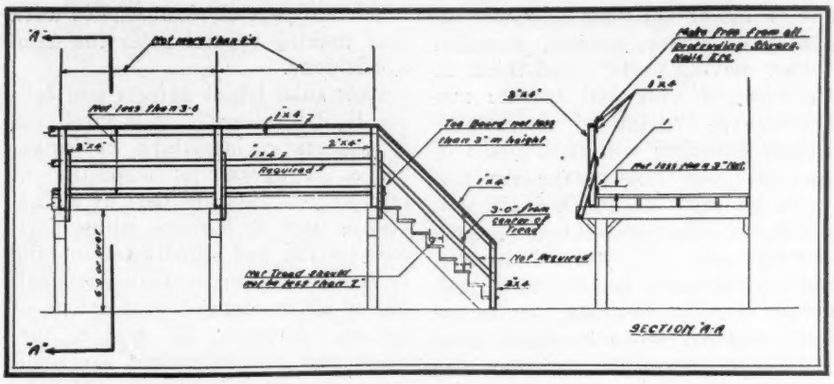
If the *Maintenance Engineering Department* is not the center of accident control, it is at least its chief ally, for all upkeep must regularly be referred to it. One advantage of placing accident prevention in this department is the avoidance of irritation which frequently results when workers or executives of one department presume to examine and criticize operating conditions or methods in another.

It is logical, therefore, for the *Maintenance Department* to centralize so-called safety work and it is consequently necessary that those responsible for it should be acquainted with the special industrial standards and the requirements of state laws. For practical needs, the "Handbook of Industrial Safety Standards" (distributed by many insurance companies) has been prepared to cover the most common features and coincides as nearly as possible with the largest number of state regulations. It is



This chart shows what safety work has accomplished in 500 plants.

This chart shows the per cent of increase and decrease of "Lost-Time Accidents" and of "Days Lost" per employee in a composite summary of 500 plants engaged in various kinds of work. Although at first there seemed to be a slight increase in accidents, after the safety work got well under way the reduction, as shown by the slope of the curve, was very pronounced.



The use of approved types of safeguards reduces the accident premium.

Whenever an inspector for a liability insurance company inspects a plant he always records whether the guards follow the approved standard and if so the plant receives recognition in reduced cost of insurance. The sketch here shows standard wood construction of railings and toeboards for stairways and platforms. This is one of the many standards which have been worked out by the engineers of the insurance companies and are available for those who wish to follow them.

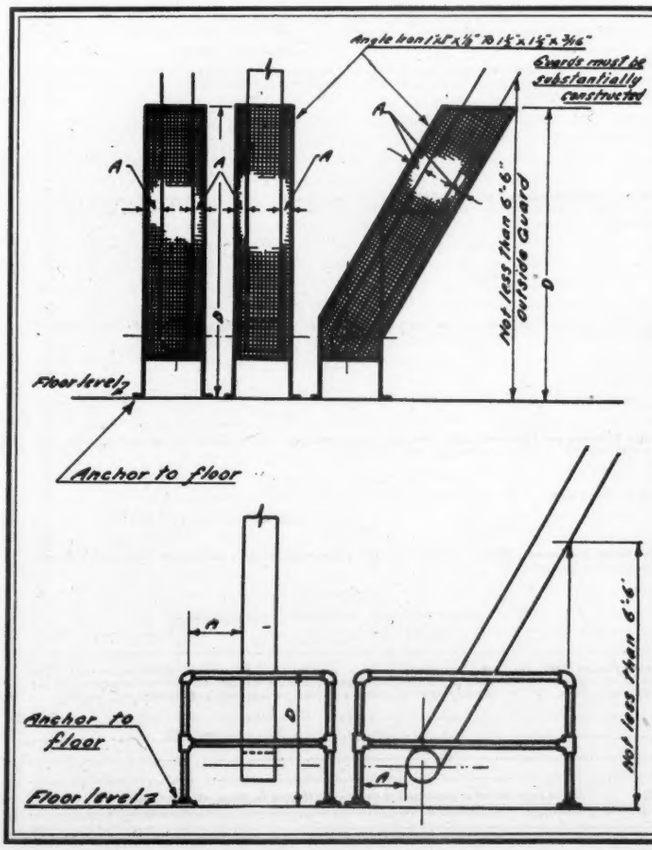
accepted by Workmen's Compensation Bureaus in Maine, New Hampshire, Vermont, New York, Pennsylvania, Maryland, Alabama, Louisiana, Tennessee, Minnesota, Massachusetts, New Jersey, Delaware, Virginia, Georgia, Texas and Kentucky. Other states have their own standards which may be obtained from the factory inspectors or other bureaus in that state responsible for their enforcement. Also a large number of other associations and organizations have issued codes or recommended practices. Perhaps one of the best known is the "National Electrical Code" issued by the National Board of Fire Underwriters, which embodies the recommendations of the National Fire Protection Association. The National Safety Council, Chicago, Ill., have also issued a number of "Safe Practice Pamphlets" which take up the construction and installation of guards and equipment as well as safe practices in the operation of equipment. A few of the subjects covered are: Ladders, stairs and stairways, cranes, belts and belt guards, oiling devices and oilers, scaffolds and many others, including altogether about sixty subjects.

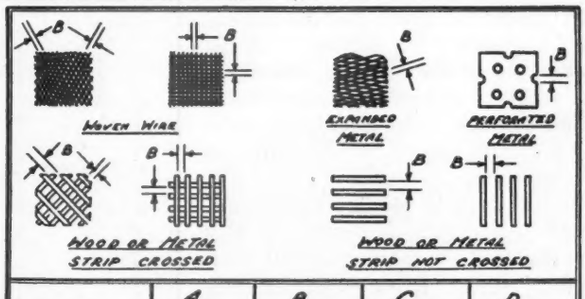
A lack of appreciation of the value of these standards by plant maintenance men has resulted in the insurance inspector (whose duty it is to establish a physical rating for each plant) finding an endless variety of sub-standard guards. So frequently is this the case that a special column is placed in the report blank for notations of this feature, and considerable physical credit is lost from this cause, when as a matter of fact a fully standard guard would not require any more labor and little more material to fulfill all requirements.

These standards have been a matter of steady growth. Starting in Europe, almost with the development of power machinery, they have constantly been revised and adjusted—not alone on theory or fancy of the compilers and inventors—but step by step as human suffering and sacrifice has pointed the way.

Human fallibility recorded in accident analysis shows failure of the human mind repeatedly under the same conditions, or at similar points in a process. Accidents at first attributed to negligence come to be so often repeated as to indicate the normal human reactions. No further argument is necessary. The process should be changed or the machine guarded.

Besides the aid to be had from the





Material	A Clearance from belt at all points	B Largest mesh or opening allowable	C Minimum Gauge (U.S. Standard or thickness)	D Minimum height of guard from floor level
Woven Wire	Under 4"	½"	½" - #20	6'-0"
	4"-15"	2"	2" - #12	5'-0"
Expanded Metal	Under 4"	½"	½" - #18	6'-0"
	4"-15"	2"	2" - #13	5'-0"
Perforated Metal	Under 4"	½"	½" - #20	6'-0"
	4"-15"	2"	2" - #14	5'-0"
Sheet Metal	Under 4"	—	#22	6'-0"
	4"-15	—	#22	5'-0"
Wood or Metal Strip Crossed	Under 4"	½"	Wood ¾"	6'-0"
	4"-15"	2"	Metal #16	5'-0"
Wood or Metal Strip not Crossed	Under 4"	½" Width	Wood ¾"	6'-0"
	4"-15"	1" Width	Metal #16	5'-0"
Std Rail	Min 15" Max 15"	Use 1½" Pipe or heavier		3'-6"

The above standard recommendations for belt guards may also be used for rope drives.

The table above shows the standards from which the guards at left may be made, as approved by the American Mutual Liability Insurance Company, Boston, Mass.

Industrial Safety Standards and existing codes, a great deal must be accomplished through the application of common sense and inventive genius.

Stamping presses, for instance, require a different guard for almost every change of set up, as far as the finger hazard or point of operation is concerned. Yet, guards are everywhere more generally used, and we find automatic feed and throw-out devices of a most ingenious order developed in some plants, making an accident practically impossible and greatly speeding production. Intensive study is necessary. Accidents with this equipment are not always caused by carelessness on the part of the employee.

Particular attention should be given to the guarding of the parts of machinery in motion which are of easy access, on aisles or corners or in narrow alleys where machines have been crowded together. Guards should prevent contact with moving parts, either from persons falling against them, backing into them or reaching through them, so that where necessary to place guards near points of dangerous contact the mesh or apertures through the guard must be correspondingly small, according to the distance of the guard from the point of danger.

Materials used depend frequently upon what is available. Consideration should be given to dust-collecting tendencies of partially closed places and consequent fire hazard, to the stability of the material to withstand damage from trucks and moving material and to corrosion in acid atmospheres.

In addition to moving equipment, which incidentally accounts for only one-fourth to one-third of all accidents, the next most important consideration might be given to so-called openings in walls or floors, and the need of handrails on all stairs of three or more risers. Even though wall openings in upper stories may be used only occasionally, they should have an auxiliary gate hinged and latched in place, when opened in summer.

Elevators, machines, gears and shaftways have many special guards and special requirements, which vary somewhat in different states. Requirements of state codes should be compared in all cases.

In considering the safety of individual machines and for insurance rating purposes, they should be regarded from three aspects: First, the means of applying power, belts, shafts or gears; second, so-called "other moving parts"; and third, in the case of over 100 specific machines, the "point of operation." Proper guarding will yield credit in each of these three particulars, and if to be guarded at all it is well worth the effort to fulfill the simple requirements of the Industrial Safety Standards so accurately that credit may be obtained, as in the lately revised schedule rating plan "point of operation" is given the largest consideration.

Value of Inspection in Accident Prevention and Maintenance

But things unseen are at times more potent than those visible. Wear-and-tear bores from within as well as from without, and the art of foreseeing latent defects and wear before they become serious and kill someone or stop the plant, is a more important part of maintenance work than making repairs after the damage is done.

How shall latent defects and failure be determined? It is vital that a systematic procedure be established. Programs of inspection at regular intervals are part of all upkeep as well as periodic oiling, periodic testing and adjustment of nuts or fastenings and periodic overhauling of all machines. Inspections of boilers, elevators, fly wheels, turbines and fire equipment are similarly important features, but why stop there? Unless the factory is so small that outside labor is called in

This standard form is recommended for reporting safety inspections.

This questionnaire type of report is similar to that used by the inspectors for the insurance companies. Plant men will find it useful in that it shows what is to be looked for and so decreases the possibility of overlooking important hazards. The reverse of the form is reproduced on the opposite page.

QUESTIONNAIRE

Plant Safety Inspection Report

This form to be used in reporting inspections made by Safety Inspector (weekly), The Workmen's Committee (monthly), General Committee (monthly). Original to be kept on file.

The man or men assigned to the safety work in this plant shall familiarize themselves with the requirements of the Handbook of Industrial Safety Standards and shall make a thorough inspection of the entire plant at the required intervals; examine carefully the condition of all buildings, stairs, fire appliances, boilers, engines, transmission machinery, belts, pulleys and working machines: note carefully the condition of present guards and give special attention with the view of installing additional safeguards. Note carefully the violation of safety rules and need of additional rules, also look for unsafe practices. New recommendations must be written out in full in space provided under each heading. The questions are only for your guidance. Make recommendations covering all unsafe conditions that it is practical to eliminate.

Recommendations shall be numbered consecutively beginning a new series each year.

Name of Assured..... Location.....

Names of Inspectors or Committee .....

.....

.....

.....Date of Inspection.....

.....Date of last Inspection.....

Recommendations Should Be Numbered Consecutively in This Column

(A) **Fire Hazard (110):** Are all fire fighting appliances ready for immediate use? Are fire exits and fire escapes clean and in good condition? Is plant kept free from excess inflammable waste and rubbish? (403). Are explosive materials properly handled and stored?

(B) **Floors (120), Floor Openings (132), Wall (134), and Hoistway Openings (136):** Are all openings properly guarded? Note condition of floors; see that floor surface is free from protruding nails, splinters, holes, slipperiness, unevenness and loose boards.

(C) **Stairs (140):** Are hand rails sufficient and substantial? Are stair treads in good condition and is light sufficient? **Ladders:** Are they in good repair; are safety feet needed?

(D) **Elevated Runways and Platforms (150):** Are they in good condition, clear of obstructions and provided with handrails and toe boards? Is material piled safely away from edge?

(E) **Transmission Equipment (320):** Are oiling platforms, ladders, belts, pulleys, shafting, set screws and other protruding revolving parts guarded?

(F) **Machine Hazard (360):** (a) State what guards are found not in use, and where guards should be provided. This should include all gears, sprockets, chains, belts, pulleys, clutches, shafting, spindles and all other dangerous revolving or reciprocating parts. (b) Are there any points of operation on these machines which can be more fully guarded?

A. M. L. 22 **To be kept on file at plant and shown to the Rating Inspector when he calls.**

for pick-up or overhauling, some further program is necessary.

When a spirit of intelligent regard for modern methods of accident prevention is active within the plant, due consideration is given to the guarding of all new equipment. It is generally much cheaper to buy a machine with the guards provided than to endeavor to supply them later. All machine makers have considered the safety of their machines, and if safeguards are specified the full standard of protection may be secured.

A surprising number of loose ends are allowed to take care of themselves until someone steps through a hole in the floor or into a vat; and his contributing negligence is blamed rather than lack of systematic pick-up.

Questionnaire Method of Reporting Plant Inspections

A brief questionnaire, similar to the one reproduced here, for this purpose has been in use for several years past by all Compensation Companies or Bureaus. A questionnaire form of inspection report is necessary in order to obtain a comprehensive view of the entire subject. A special form applicable to the particular plant should be made up where considerable difference exists, omitting items which do not apply and adding or amplifying others which do.

Recommendations for all repairs should be entered in respective headings and numbered, and where sufficient recommendations result a separate list should be kept which can the more readily be followed up and checked off as the work is completed and with which the order slips to various repair departments may be compared.

With the "old timer" it is much easier to go out with a hammer and eliminate the difficulty at once, rather than to report it, and only an occasional record results. This fails in the purpose of developing interest in work accomplished and in developing a record which can later become the basis of estimate of future maintenance requirements which become more and more important as the age of the plant increases.

There is also a habit of refraining from reporting items requiring unusual consideration, such as, lighting, ventilation, re-arrangement of machines as well as structural building changes. There is a feeling that the record will look bad or that it would be useless to record items beyond the reach of immediate accomplishment. This is an erroneous point of view, as these ideas will be invaluable when the opportunity comes for larger development.

With the foregoing record made at least weekly in plants involving manufacturing hazards and employing over a hundred employees, a very considerable start has been made toward the accident control plan which has been applied most successfully in a great number and variety of industries.

Why It Is Necessary to Do More Than Provide Safeguards

It has been long known that after the fundamental guarding has been accomplished something more was necessary to prevent accidents, as only one-fourth to one-third of all accidents might be attributed to machines. A brief consideration of the various causes of accidents shows that the workmen need instruction in the dangers of their work; that the thoughtless should be reminded and that in order to obtain the co-operation of the workers in an effort to save them from suffering, their active participation in an accident prevention routine is necessary.

The full plan of accident control or safety organization, as developed in the Industrial Safety Standards, has warranted a direct reduction in schedule rate of 5 to 15 per cent. This credit is only a preliminary benefit, as through reduction of losses the experience features of the present rating plan allow credit for

This is the remainder of the questionnaire plant safety inspection report shown on the opposite page.

It is recommended that these reports be made weekly by a safety inspector for the plant, and by a workmen's committee and a general committee monthly.

Recommendations Should Be Numbered Consecutively in This Column

(G) **Elevators and Other Hoisting Equipment (170):** Note condition of signal system, cables, safety devices, gates, car and shaftway protection, car and landing lighting.

(H) **Power Traveling (Bridge) Cranes (160):** Note condition of footwalk, railing ladders and safety appliances. Is signal used to guard workmen? Are chains, slings and hoist cables inspected?

(I) **Electrical Equipment (212):** Note condition of switchboard, transformers, wiring and controlling and operating apparatus and see that they are properly protected or isolated.

(J) **Boilers, Pressure Apparatus (200), Steam, Gas and Oil Engines (300):** How often blown down and washed—are safety valves and water gauges tested daily—are speed limits of engines tested daily? Are moving parts safeguarded?

(K) **Handling Material:** Trucking passageways, light, obstructed view at corners, railroad access, hoists needed, piling and storing, yard conditions, nails, glass, sharp edges, hand tools, acids, caustics, gases, dusts.

(L) **First Aid:** Note if sufficient supplies, cleanliness, easy access, stretcher. Goggles, respirators, foundry shoes and leggings—are they available?

(M) **Sanitation:** Note light, windows clean, lamps need shades, ventilation, drinking water, washing facilities, clothes lockers, condition of toilets, cuspidors. General housekeeping.

(N) **Bulletins** **Quantity Posted**

(O) **Accidents Investigated:**

Date	Name	How It Happened

(P) **Recommendations Summarized.** **Individual Numbers** **Total**

I. Submitted.
II. Completed.
III. Under progress.
IV. Not begun.

One of the first steps in accident prevention is to make an analysis of the causes of accidents in your plant as is done for an industry here.

The prevention of accidents from non-mechanical causes may best be obtained through education and training of the men in the importance of safety because the larger proportion are the result of carelessness and so cannot be prevented by safeguards. Part of the accidents from mechanical causes can be prevented by guards but here education is also important. "The best safeguard is a careful man," is an axiom of industrial accident prevention. Handling material is the largest single cause of accidents.

reduced accident loss amounting in some cases to 40 or 50 per cent.

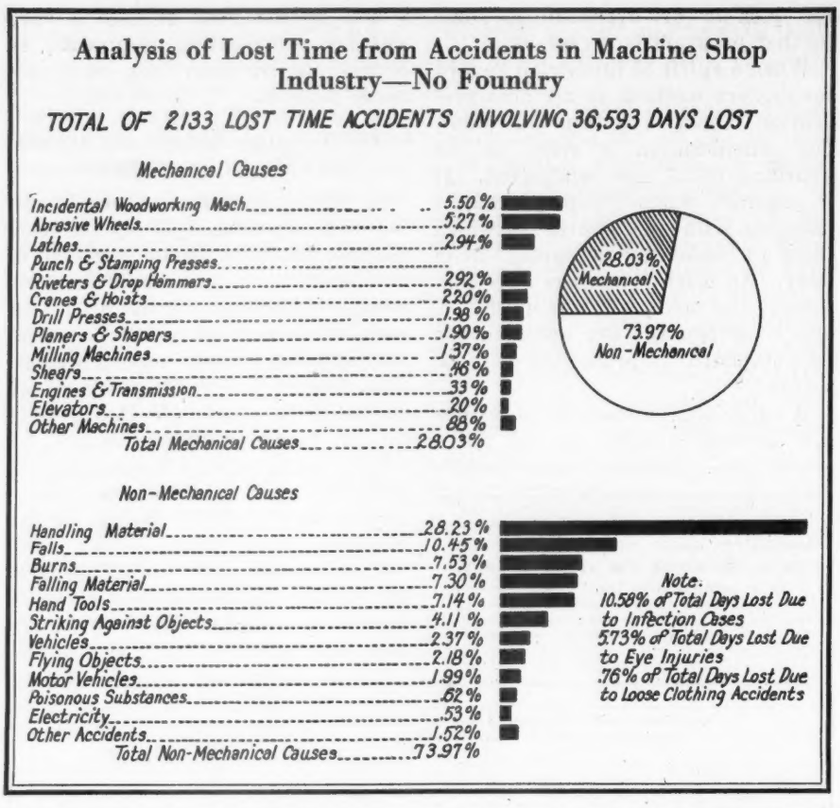
Plans for safety organization are developed according to the size of the plant based on the number of employees, and generally center about the maintenance departments. Plants containing up to 150 employees, with normal manufacturing dangers, require a Supervisory Committee in addition to the weekly inspections previously described. Supervision of maintenance would exist in any case, and for the purposes here contemplated it is required that a committee of three or more of those in authority meet once a month and review inspection reports and accidents and authorize action.

Management and Employees Must Both Show Interest in Safety

An interest in, or special consideration of, safety at least once a month, on the part of the management, is a condition quite as necessary as the interest of the workers. In plants up to 500 employees, a monthly inspection by the Committee (or by selected members of it) should be added and some method should be used at least twice a year to speak to the employees in groups or as a body, on accident prevention questions.

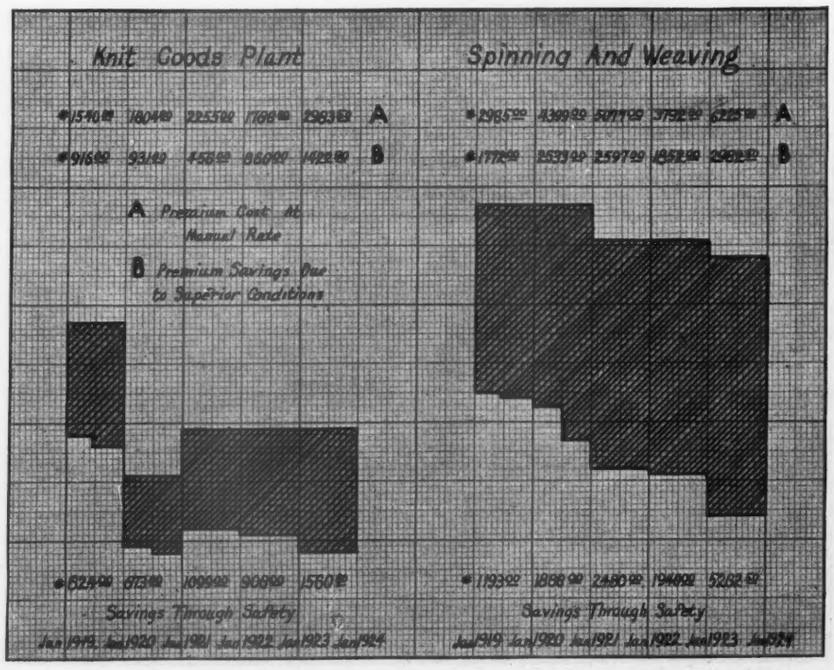
Credit for organization in plants of over 500 employees, substitutes a Workmen's Committee of inspection for the single committee. Other details are retained.

The primary requisite for reduced cost of accidents is a well-kept plant.


Analysis of Lost Time from Accidents in Machine Shop Industry—No Foundry
TOTAL OF 2133 LOST TIME ACCIDENTS INVOLVING 36,593 DAYS LOST
Mechanical Causes
Incidental Woodworking Mach. 5.50 %
Abrasive Wheels 5.27 %
Lathes 2.94 %
Punch & Stamping Presses
Riveters & Drop Hammers 2.92 %
Cranes & Hoists 2.20 %
Drill Presses 1.98 %
Planers & Shapers 1.90 %
Milling Machines 1.37 %
Shears .46 %
Engines & Transmission .33 %
Elevators .20 %
Other Machines .88 %
Total Mechanical Causes 28.03 %
28.03% Mechanical
73.97% Non-Mechanical
Non-Mechanical Causes
Handling Material 28.23 %
Falls 10.45 %
Burns 7.53 %
Falling Material 7.30 %
Hand Tools 7.14 %
Striking Against Objects 4.11 %
Vehicles 2.37 %
Flying Objects 2.18 %
Motor Vehicles 1.99 %
Poisonous Substances .62 %
Electricity .53 %
Other Accidents 1.52 %
Total Non-Mechanical Causes 73.97 %
Note.
10.58% of Total Days Lost Due to Infection Cases
5.73% of Total Days Lost Due to Eye Injuries
.76% of Total Days Lost Due to Loose Clothing Accidents

That means systematic maintenance. last and the repair man is obliged to "run in" the guarding of machines Too often safeguarding is left to the here and there when he gets a chance after supposedly more important machine changes have been made. He will do what he is told in all events and it depends on management to set up a definite system that will follow up safety recommendations.

After that, with a lowered ratio of mechanically caused accidents, it is time to attack the non-mechanical accidents through education, but always and forever there will be that need of inspection, follow-up and repair—the duty of maintenance. The repair man stands in the way to offset the ever-rising tide of the cost of industrial accidents, if you give him a chance. The responsibility rests with the management.



Savings made in two departments as a result of organized safety work.

The shaded area shows the reduction in premium for liability insurance in a textile mill after safety had been conducted on an organized basis. The top line *A* of the shaded area represents the amount of insurance at the manual rate for average safety conditions. The lower line *B* of the shaded area shows the actual premium paid after the safety work was put on an organized basis. The actual savings in dollars are given just below and are represented by the shaded areas.

Step-by-Step Methods of

Laying Out Wave Windings for A.C. Motors

Complete With Diagrams Showing Windings at Different Stages of a Job Together With Details of Series-star and Series-delta Connections and How The Coils and Sections may be Paralleled

THIS is the second of a series of articles on alternating-current wave windings. The first article, which was published in the September issue, explained how to lay out and construct a wave winding for two-phase and single-phase stators having two-layer windings. This article explains how the construction and rules are applied to three-phase windings of this type. Winding more than two coils per cell and methods of paralleling coils are also discussed. A succeeding article will give short-cut methods and tabulations of data for use in laying out this type of winding.

By A. C. ROE

Renewal Parts Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh Pa.

THE previous article in the September issue explained how to lay out and construct two-layer wave windings for two-phase and single-phase stators. The construction and rules as applied to three-phase windings of this type, will be taken up in this article.

We will first lay out a series-star winding for a four-pole, three-phase stator having twenty-four slots and twenty-four coils. As was done in the previous article, the data and calculation will be tabulated as follows:

(1) Number of slots—24
(2) Number of phases—3
(3) Number of poles—4
(4) Number of coils—24

The first four items are taken from the data given in the description of the winding in the preceding paragraph.

(5) Number of coils per slot equals total number of coils divided by total number of slots, or $24 \div 24 = 1$

(6) Number of sections, according to *Rule 3* (given in the box on page 486) will be equal to twice the number of phases, or $2 \times 3 = 6$

(7) Number of coils per section equals total number of coils divided by total number of sections, or $24 \div 6 = 4$

(8) Number of coils in a series, according to *Rule 1*, is equal to one-half the number of poles in the winding, or $4 \div 2 = 2$

(9) Number of series of coils in a section equals number of coils per section (see item 7) divided by number of coils in a series (see item 8), or $4 \div 2 = 2$

(10) Number of coil groups, according to *Rule 4*, equals number of phases times number of poles, or $3 \times 4 = 12$, making twelve pole-phase groups

(11) Number of coils per group equals total number of coils divided by the total number of groups, or $24 \div 12 = 2$

(12) Number of coils per phase equals total number of coils divided by number of phases, or $24 \div 3 = 8$

(13) Winding pitch equals total number of slots divided by half the number of poles, or $24 \div 2 = 12$; that is, the total winding pitch will be 1-and-13

(14) The back pitch is equal to one-half the winding pitch, or $12 \div 2 = 6$, which is a back pitch of 1-and-7

(15) The front pitch is equal to the total winding pitch minus the back pitch, or $12 - 6 = 6$, which is a front pitch of 1-and-7.

The winding resulting from the above data and calculations, and in particular from items 6, 7, 8 and 9, will have two sections per phase or a total of six sections, each section having four coils arranged in two series of two coils each. A left-hand winding will be laid out.

The first step is to draw the four circles and slots as was explained for a two-phase winding in the previous article. These four circles are shown in light lines in Fig. 1. The two inner circles are to mark the limit of the slots and the two outer circles are to mark the limit of connections between slots. Since there are two coil sides in each slot for this winding, two lines are drawn in each slot, the bottom coil side being represented by a dotted line and the top coil side being represented by a full line. Starting with a top coil half or conductor in any slot, say slot *2*, draw in the lead A_1 as shown in Fig. 1.

Counting in a clockwise direction from slot *2*, a distance equal to the back pitch of 6, we arrive at slot *8*. Slots *2* and *8* are to be connected on the back by the connectors as is shown in the diagram. The bottom coil half is used in slot *8*. Counting in a clockwise direction from slot *8*, a distance equal to a front pitch of 6, we arrive at slot *14*. The front end of the bottom coil half in slot *8* and the front end of the top coil half in slot *14* are to be connected as is shown in the diagram. In a similar manner we connect the back end of the top coil half in slot *14* with the back end of the bottom coil half in slot *20*. This is the end of the first series of two coils in the first section of the first or *A* phase. Since there is always a short pitch between the end of one series and the beginning of the succeeding series, the front end of the bottom coil half in slot *20* is connected to the front end of the top coil half in slot *1* as is shown in Fig. 1. These two coil sides are a short pitch of five slots apart.

Continuing on through the second series and using a front pitch and back pitch of 6 we connect slots *1* and *7* on the back, slots *7* and *13* on the front, and slots *13* and *19* on the back and carry the front end of slot *19* to R_1. This is all shown in Fig. 1. This finishes the first section of the *A* phase.

The location of the R_1 lead, that is, the end of the first section, could have been determined from *Rule 7*. According to this rule the R_1 lead will fall behind or ahead of the A_1 lead and a number of slots that is equal to the front pitch plus one less than the number of coils per group; that is, in the case of this winding the R_1 lead will be a distance away from the A_1 lead, measured in a counter-clockwise direction, of 6+2–1=7 slots. Counting in a counter-clockwise direction from the slot in which the A_1 lead is connected, that is, slot *2*, a distance of seven slots, we arrive at slot *19* which, as we found before, was the location of the R_1 lead.

The R_2 lead, that is, the start of the second section, can be located by

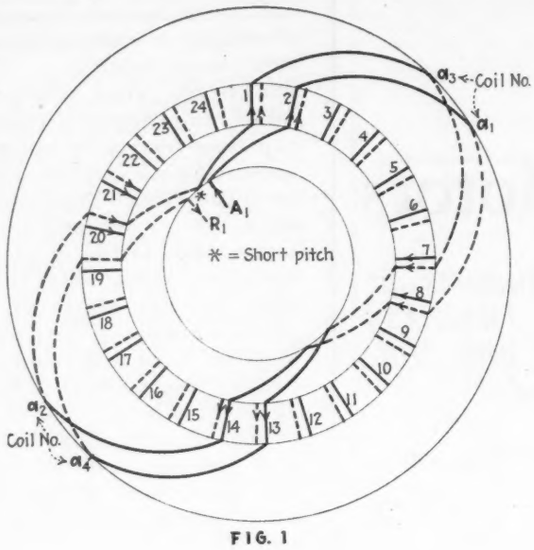


FIG. 1

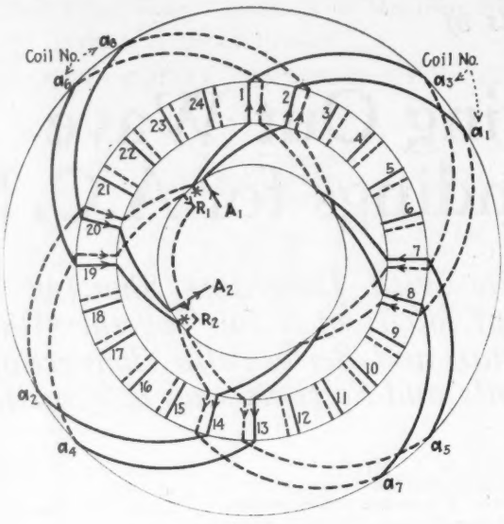


FIG. 2

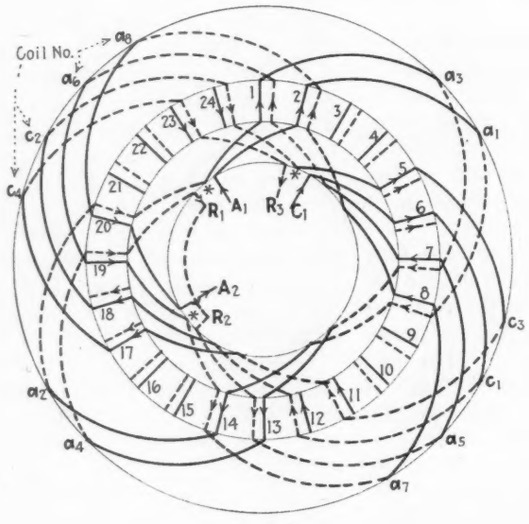


FIG. 3

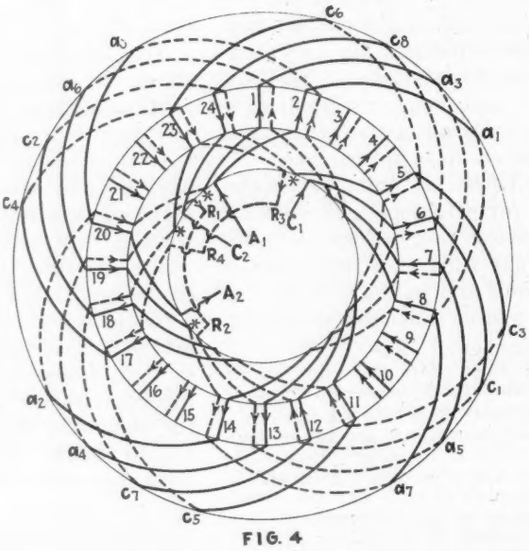


FIG. 4

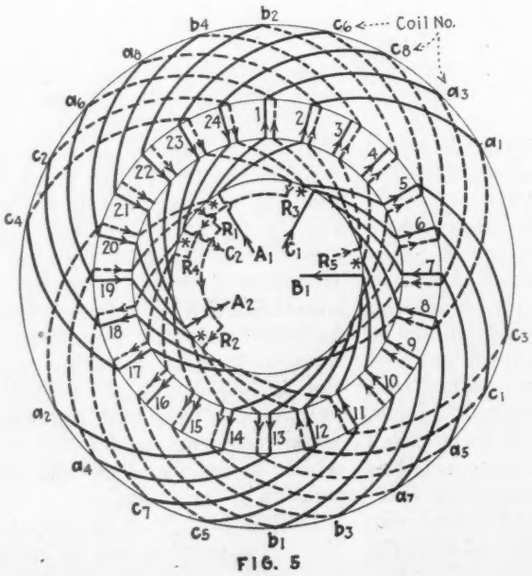


FIG. 5

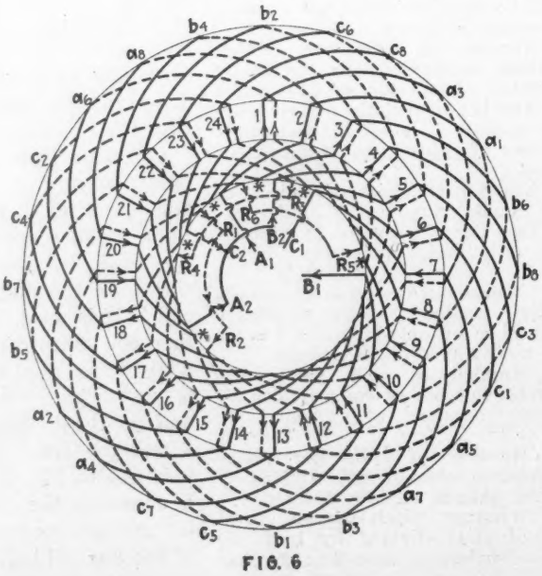


FIG. 6

Figs. 1 to 6—Progressive stages in the construction of a four-pole, three-phase, series-star wave winding for an induction motor.

This winding is a two-layer winding having twenty-four slots and coils with two sections per phase, each section arranged in two series of two coils each. The first section of the *A* phase is shown in Fig. 1. The *A* phase has been completed in Fig 2. Fig 3 shows the *A* phase together with the first section of the *C* phase. Fig. 4 shows the *A* and *C* phases complete. In Fig. 5 the first section of the *B* phase has been added. Fig. 6 shows the complete winding diagram for the stator.

means of *Rule 8*. According to this rule, the R_2 lead will fall in a slot that is a distance of one front pitch or six slots, measured in a counter-clockwise direction, from slot *19*; that is, it will fall in slot *13*. This is shown in Fig. 2.

According to *Rule 9*, for this winding the A_2 lead will be located in a slot that is one front pitch, measured in a counter-clockwise direction, from A_1. Counting a distance of six slots in a counter-clockwise direction from slot *2*, we arrive at slot *20*, which is the location of the A_2 lead. According to *Rule 10*, since A_1 connects to a top conductor, A_2 will also be connected to a top conductor; therefore, A_2 will connect to the top conductor in slot *20*.

There are several considerations affecting the determination of the starting point of the next phase. Since there are twenty-four slots and four poles there will be 24÷4=6 slots per pole. Of the six slots for each pole, two slots will be occupied by the *A* phase, two by the *B* phase and two by the *C* phase. All of these slots must have the same polarity; that is, at any one instant the current must be passing through all six slots in the same direction. In Fig. 2, the *A* phase was started in slot *2*. The direction of flow of the current is taken to be into the winding on the lead A_1; hence the arrows on A_1 and the top conductor in slot *2* will be in the direction shown. Tracing through the remaining slots of the *A* phase the arrows are placed in the *A*-phase slots in the direction of travel, as is shown in Fig. 2. This determines the instantaneous polarity of all the *A*-phase slots.

In a three-phase winding, the instantaneous polarity of the phase leads A_1, B_1, and C_1, must be such that any two of them are leading into the winding and the remaining one leads out. That is, if A_1 leads in and we make B_1 lead out, then C_1 must lead into the winding. Or, if A_1 and B_1 lead in, then C_1 leads out. If A_1 leads out then B_1 and C_1 must lead in. In this winding we will take the direction of flow such as to make the A_1 and C_1 leads go into the winding. Consequently, B_1 must lead out of the winding.

In a three-phase winding we will have twelve leads in all: a start and a finish for each phase, which accounts for six leads; and two reversing jumper leads (R_1, R_2, R_3, etc.) for each phase, which accounts for the other six. In a four- or six-pole machine it will be impossible to arrange the winding so as to prevent the crossing of these twelve leads; hence, the starting leads of the phases are placed as close together as conditions will permit. Since the A_1 lead is in slot *2*, we will place the C_1 lead as close to it as possible.

Based on the conclusion of the two preceding paragraphs we may start the *C* phase in slot *24*, or in slot *6*. If the phase is started in slot *24*, slot *23* will be the other slot for the *C* phase in the pole group that includes slots *1* and *2*. Likewise, if the *C* phase is started in slot *6*, slot *5* will be the other slot for the *C* phase in this pole group. Slots *3* and *4* are reserved for the *B* phase so as to keep the phases in order; that is, in the order *A*, *B*, *C*.

We will start the C_1 lead in slot *6*. Then R_3, according to *Rule 7*, will be a distance of 6+2–1=7 slots, measured in a counter-clockwise direction, from slot *6* (that is, the slot to which the C_1 lead connects). Counting seven slots in a counter-clockwise direction from slot *6* we arrive at slot *23*, which is the location of the slot to which the R_3 lead connects. According to this same rule R_3 will connect to a bottom conductor. This is shown in Fig. 3. According to *Rule 8*, R_4 will be six slots, measured in a counter-clockwise direction, from slot *23*, that is, in slot *17*, as is shown in Fig. 4, and will be connected to a bottom conductor. According to *Rules 9* and *10*, the finishing lead C_2 will connect to a top conductor located in a slot that is six slots, measured in a counter-clockwise direction, from slot *6* (slot with which C_1 connects); that is, C_2 will fall in slot *24*. Fig. 4 shows the *C* phase drawn in complete.

We could have started the *C* phase in slot *24*, slot *12* or slot *18*, instead of slot *6*. Having selected slot *6* and because we have said that A_1 and B_1 must have the same instantaneous polarity, that is, both of them will lead into the winding, then slots *1*, *2*, *3*, *4*, *5* and *6* must all be of the same polarity and constitute one pole. If we had started the *C* phase in slot *24*, we would have made slots *23*, *24*, *1*, *2*, *3* and *4* the same polarity. Having decided that slots *1* to *6* inclusive form one pole, then it follows that slots *7* to *12* inclusive form another pole, slots *13* to *18* inclusive form the third pole and slots *19* to *24* form the fourth pole. We know the polarity of slots *1* to *6* because A_1 and C_1 must lead into the winding. The arrows in the slots in Figs. 1, 2 and 3 indicate the polarity of the slots in which we have wound the *A* and *C* phases. Since we know the slots in each pole group and that all slots in a pole group must be of the same polarity and also that adjacent poles must be of opposite polarity, it is easy to draw in the arrows indicating the polarity of each slot. This has been done in Fig. 4.

This diagram shows that the slots remaining for the *B* phase are slots *3*, *4*, *9*, *10*, *15*, *16*, *21* and *22*. The winding cannot be started in slots *3*, *4*, *13* or *14* because we have said that the B_1 lead must have the opposite polarity from A_1 and C_1 and hence, must lead out of the winding. This leaves slots *9*, *10*, *21* and *22*. Slots *9* and *21* can be disregarded because the second series of coils will fall in these slots. Slots *10* and *20* remain for the start of the *B* phase. The conclusion may be drawn from this that once we have selected the starting point of two phases, we have only two places left in which we can start the third phase in a four-pole machine, three places in a six-pole machine, and so forth.

We will choose slot *10* as the start of the *B* phase; hence the B_1 lead will connect to a conductor in slot *10*. Since we have started the A_1 and the C_1 lead in top conductors we will have to connect the B_1 lead to a top conductor. The first section of the *B* phase is shown in Fig. 5. According to *Rule 7*, R_5 will be a distance of 6+2–1=7 slots, measured in a counter-clockwise direction, from slot *10* and will connect to a bottom conductor. Counting seven slots in a counter-clockwise direction from slot *10* we arrive at slot *3* which is the location of R_5. This is shown in Fig. 5. According to *Rule 8*, R_6 will be six slots, measured in a counter-clockwise direction, from slot *3*; that is, in slot *21* and will connect to a bottom conductor in that slot. This is shown in Fig. 6. According to *Rule 9*, B_2 will be located in a slot that is six slots, measured in a counter-clockwise direction, from slot *10*; that is, in slot *4*. According to *Rule*

These Rules for Laying Out Wave Windings Were Derived in the First Article of this Series

Rule 1—The number of coils in a series is equal to one-half the number of poles in the winding.

Rule 2—The number of series of coils equals the number of slots per pole per phase, which is equal to the number of slots divided by the number of poles and this result divided by the number of phases.

Rule 3—The number of sections equals twice the number of phases; that is, each phase will have two sections.

Rule 4—The number of coil groups is equal to the number of poles multiplied by the number of phases.

Rule 5—Between the starting and finishing leads of each section there will occur a number of short pitches equal to one less than the number of slots per pole per phase.

Rule 6—The reversing jumper lead (that is, R_1, R_2, R_3, R_4, R_5, etc.) and the finishing lead of the phases (that is, A_2, B_2, C_2) are on the left of their respective phase starting lead (that is, A_1, B_1, C_1), for a left-hand winding and on the right for a right-hand winding.

Rule 7—The first reversing jumper of a phase (that is, R_1 for A phase, R_3 for B phase, or R_5 for C phase) will be located in a slot that is a number of slots from the phase starting slot (A_1, B_1, or C_1, as the case may be) equal to the front pitch plus one less than the number of coils per group, measured in a counter-clockwise direction for a left-hand winding and measured in a clockwise direction for a right-hand winding. Also, if the starting lead (A_1, B_1, or C_1) goes to a top conductor, then the reversing jumper lead is connected to a bottom conductor.

Rule 8—The second reversing jumper lead for a given phase (R_2, R_4, or R_6) is connected to a bottom coil half or conductor when the first reversing jumper is connected to a bottom conductor and *vice versa*, and is spaced one front pitch measured in a counter-clockwise direction from the first reversing jumper for a left-hand winding and measured in a clockwise direction for a right-hand winding.

Rule 9—The finishing lead of a phase (A_2, B_2, or C_2), will connect to a conductor located in a slot that is one front pitch from the starting lead of that phase and is measured in a counter-clockwise direction for a left-hand winding and in a clockwise direction for a right-hand winding.

Rule 10—If the starting lead of a phase connects to a top conductor or coil half, then the finishing lead of that phase will connect to a top conductor, or *vice versa*.

10, B_2 will connect to the top conductor in that slot.

The ends of the three phases, that is, A_2, B_2 and C_2 are connected together to form a star jumper. The completed winding is shown in Fig. 6.

If we had decided to use the bottom coil halves in the slots for the line and star connections, the diagram would have to be numbered in the opposite direction to that shown in Fig. 6, that is, the numbers would run counter-clockwise, but the other rules would hold true.

In practice, it is not necessary to draw in all the coils together with all their front and rear connections as this would require considerable time for stators having a large number of slots and more than one coil per cell. All that is needed is a working diagram showing the slots to which the leads are connected, and which slot the short pitches and reversing jumpers fall in. In fact, some manufacturers only show one phase, or part of a phase, and give the rest in slot numbers.

Comparing Figs. 7 and 8 will give an idea of the amount of time that can be saved by not having to draw the complete diagram. If the total number of coils in a winding is large, the diagram can be simplified by just drawing the back connections of one series of coils for one phase only, as is shown in Fig. 8 in

Figs. 7 and 8—Considerable time and effort can be saved by making working diagrams instead of complete winding diagrams.

Fig. 7 shows the complete winding diagram for a two-phase, twenty-four-slot, two-layer winding. Fig. 8 is a working diagram for the same winding. In this diagram the information that the winder needs is given directly without the necessity of tracing through a maze of confusing lines.

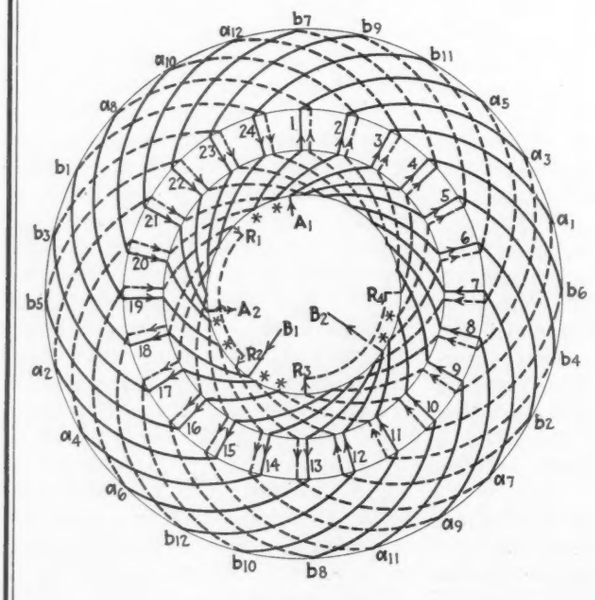
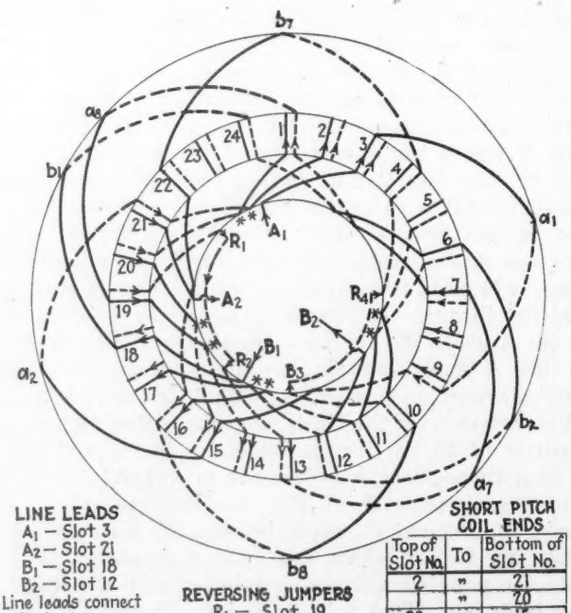


FIG. 7



LINE LEADS
A_1 — Slot 3
A_2 — Slot 21
B_1 — Slot 18
B_2 — Slot 12
Line leads connect only to top conductors

REVERSING JUMPERS
R_1 — Slot 19
R_2 — Slot 13
R_3 — Slot 10
R_4 — Slot 4
Reversing jumpers connect only to bottom conductors

FIG. 8

SHORT PITCH COIL ENDS

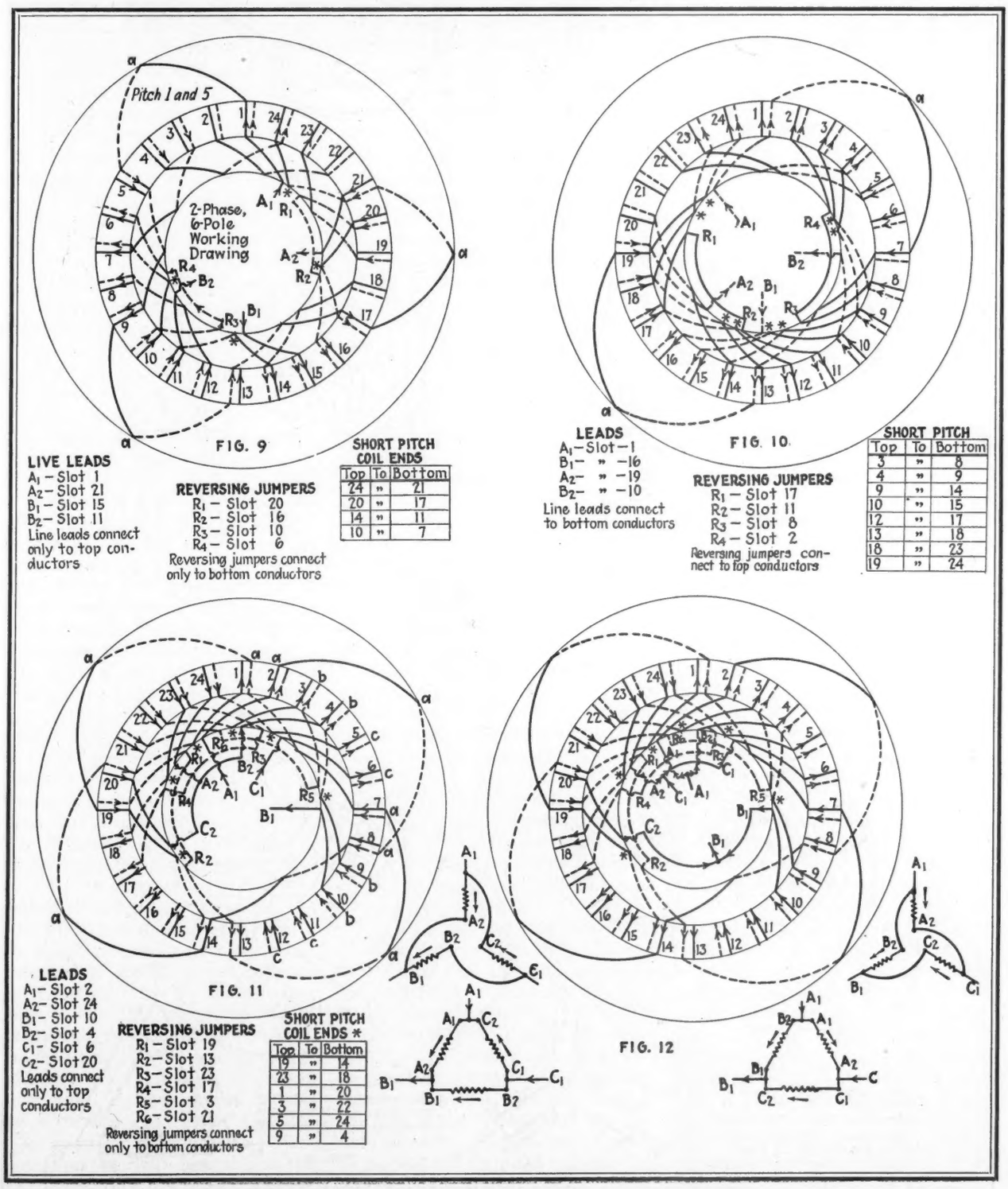
Top of Slot No.	To	Bottom of Slot No.
2	"	21
1	"	20
20	"	15
19	"	14
17	"	12
16	"	11
11	"	6
10	"	5

the back connections of coils *a*1 and *a*2. The reason that the back connections are not required on the diagram is that in the usual two-layer wave winding, the coil forms a complete unit; that is, the top and bottom halves of the coil are permanently joined together at the rear and thus the back pitch is permanently established. Consequently, all that need be shown is the front connection and the proper notation.

Figs. 9 to 12—Working diagrams for two- and three-phase motors showing series-star and series-delta connections for the latter type.

Figs. 9 and 10 are for two-phase motors. The former is for a six-pole, series winding having twenty-four coils and slots. The latter is for a four-pole, series winding having the same number of coils and slots. Fig. 11 is the working diagram for the three-phase, series-star, four-pole winding which is shown complete in Fig. 6. In Fig. 12 is shown the working diagram of a series-delta connection of the winding that is shown connected series-star in Fig. 11. The small sketches at the bottom of Fig. 12 show two ways of making the series-delta connection.

Fig. 7 gives the complete winding diagram for the two-phase, twenty-four coils and slots, winding which was worked out in the first article of this series on wave windings and is the same as Fig. 20 of that article. Fig. 8 gives the working diagram for this same winding. The tabulation at the lower right-hand corner gives the location of the short pitches. This table shows that the top conductor in slot *2* should con-


Pitch 1 and 5
2-Phase, 6-Pole Working Drawing
FIG. 9
LIVE LEADS
A1 – Slot 1
A2 – Slot 21
B1 – Slot 15
B2 – Slot 11
Line leads connect only to top conductors
REVERSING JUMPERS
R1 – Slot 20
R2 – Slot 16
R3 – Slot 10
R4 – Slot 6
Reversing jumpers connect only to bottom conductors
SHORT PITCH COIL ENDS
Top | To | Bottom
24 | " | 21
20 | " | 17
14 | " | 11
10 | " | 7
FIG. 10
LEADS
A1 – Slot – 1
B1 – " – 16
A2 – " – 19
B2 – " – 10
Line leads connect to bottom conductors
REVERSING JUMPERS
R1 – Slot 17
R2 – Slot 11
R3 – Slot 8
R4 – Slot 2
Reversing jumpers connect to top conductors
SHORT PITCH
Top | To | Bottom
3 | " | 8
4 | " | 9
9 | " | 14
10 | " | 15
12 | " | 17
13 | " | 18
18 | " | 23
19 | " | 24
FIG. 11
LEADS
A1 – Slot 2
A2 – Slot 24
B1 – Slot 10
B2 – Slot 4
C1 – Slot 6
C2 – Slot 20
Leads connect only to top conductors
REVERSING JUMPERS
R1 – Slot 19
R2 – Slot 13
R3 – Slot 23
R4 – Slot 17
R5 – Slot 3
R6 – Slot 21
Reversing jumpers connect only to bottom conductors
SHORT PITCH COIL ENDS *
Top | To | Bottom
19 | " | 14
23 | " | 18
1 | " | 20
3 | " | 22
5 | " | 24
9 | " | 4
FIG. 12

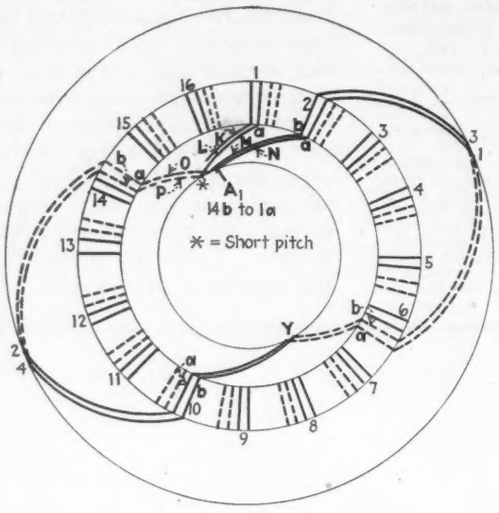


FIG. 13

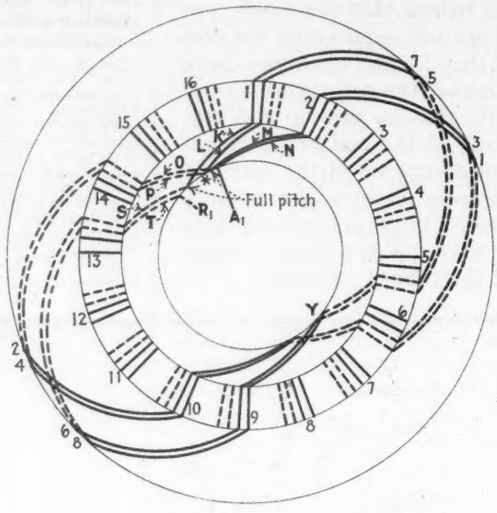


FIG. 14

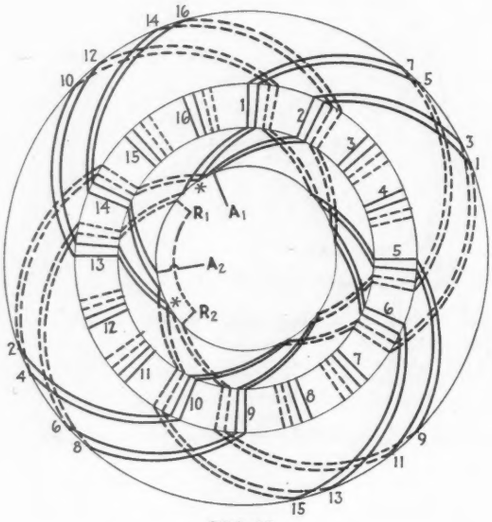


FIG. 15

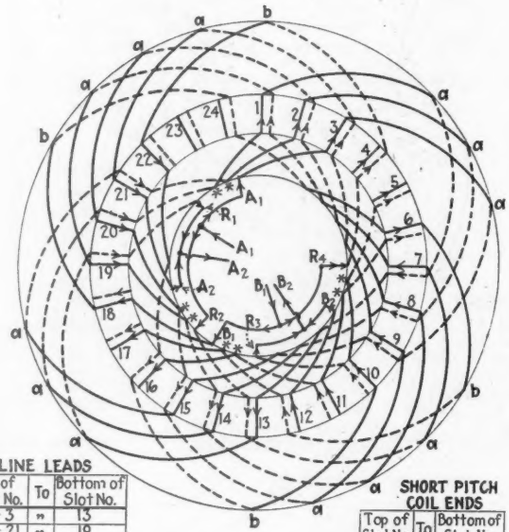


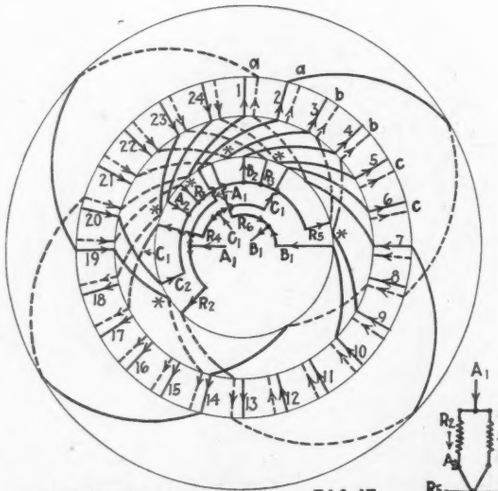
FIG. 16

LINE LEADS

Top of Slot No.	To	Bottom of Slot No.
A_1 – 3	"	13
A_2 – 21	"	19
B_1 – 18	"	4
B_2 – 12	"	10

SHORT PITCH COIL ENDS

Top of Slot No.	To	Bottom of Slot No.
1	"	20
2	"	21
10	"	5
11	"	6
16	"	11
17	"	12
19	"	14
20	"	15



A-phase leads: Top 2; bottom 13
B-phase leads: Top 10; bottom 21
C-phase leads: Top 6; bottom 17

Top conductors 20, 24, 4 and bottom conductors 19, 23, 3 connect to star ring

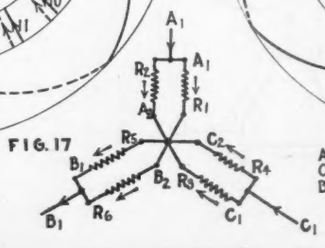
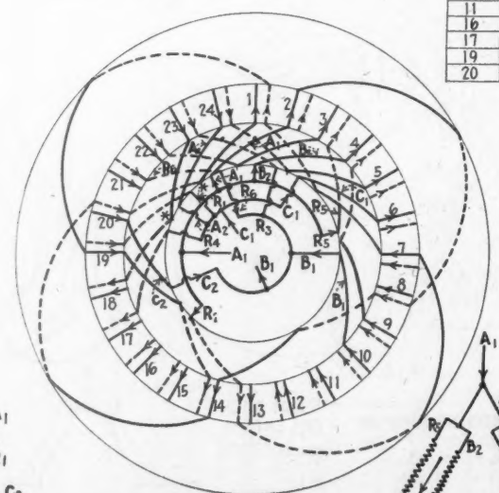


FIG. 17



A-phase leads: Top 2-4; bottom 3-13
C-phase leads: Top 6-24; bottom 17-19
B-phase leads: Top 10-20; bottom 21-23

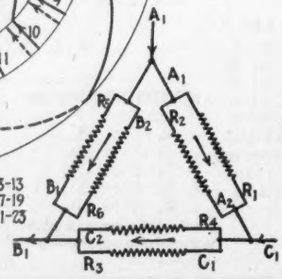


FIG. 18

Figs. 13 to 18—Diagrams showing different stages in making windings having four conductors per slot and how to make two-parallel star- and delta-connected windings.

Figs. 13 to 15 show three stages in making a two-phase, four-pole, sixteen-coils-and-slots winding having four conductors per slot. Fig. 13 shows how the first series of coils is connected to the second series. Fig. 14 shows the first section of one phase complete. Fig. 15 shows a complete phase. In Fig. 16 is shown the working diagram for a two-phase winding connected two-parallel. Fig. 17 shows a two-parallel, star-connected winding, while Fig. 18 is the same winding connected two-parallel delta.

nect to the bottom conductor in slot *21*; also the top conductor in slot *1* connects to the bottom conductor in slot *20*, and so on. The tabulation at the bottom of Fig. 8 gives the location of the reversing jumpers and the starting and finishing leads of each phase. The information given in Fig. 8 is of greater help to the winder than that given in Fig. 7 because in the former the winder would have to trace out the location of the short pitches whereas in the latter it is given to him directly and with less confusing lines.

Fig. 9 shows a working diagram together with all the necessary winding data for a six-pole, two-phase winding. This is a right-hand winding. Notice how the slots are numbered and that the rules which have been given before check this fact.

In Fig. 10 is shown a working diagram for a four-pole, two-phase, right-hand winding having the line leads connected to bottom conductors. Notice that the numbering of the slots in this case is the same as for a left-hand winding with line leads connected to top conductors.

In Fig. 11 is shown the working diagram for the three-phase, series-star winding which is shown complete in Fig. 6.

Up to the present we have considered windings with only one coil per cell, but in many cases there are two, three, and sometimes four coils per cell. These windings will give the winder more trouble than the single-coil job if he does not understand the method of picking up the series.

In Fig. 13 is shown the start of a two-phase, four-pole winding with sixteen slots and thirty-two coils, or two coils per cell. In any one slot there will be two top conductors or straps and two bottom conductors. The following rule must be observed:

Rule 11—In a left-hand winding in which the line leads are to be connected to top conductors, the line leads must connect to the top conductors on the right-hand side of the slot, while the reversing jumpers connect to bottom conductors on the left-hand side of the slot. When the line leads connect to bottom conductors, the bottom conductors on the left-hand side of the slot must be used and the reversing jumpers will connect to top conductors on the right-hand side of the slot. The opposite holds true for a right-hand winding; that is, with line leads connecting to top conductors, use left-hand top conductors, and the reversing jumpers will connect to right-hand bottom conductors. Also, if the line leads connect to bottom conductors, use right-hand bottom conductors for line leads and connect the reversing jumpers to left-hand top conductors.

Since the winding shown in Fig. 13 is a left-hand winding, according to the above rule, we will connect the line lead A_1 to the right-hand top conductor in slot *2* as shown. The rear end of this conductor is connected to the rear of the right-hand bottom conductor in slot *6*, for the back pitch is 1-and-5. The winding continues through top and bottom conductors alternately, the conductors marked *a* in slots *6*, *10* and *14* being used. This completes the first series of coils. The *a* conductor in slot *14* is connected to the start of the second series of coils. A full pitch in slots is used and the start is made on the *b* conductor in slot *2*. We then connect up the series of *b* conductors in the same slots used before until we reach the bottom of slot *14*. This completes two series of coils. Each slot has been passed through twice.

To continue the section, we connect the *b* conductor to the top conductor in slot *1*; that is, we drop one slot, making a short front pitch. From this we derive the following rule:

Rule 12—When there is more than one coil per cell, we pass completely around the winding as many times as there are conductors or coil sides per cell before we use the short (one slot less) front pitch.

Fig. 13 illustrates this rule. Fig. 14 shows one complete section drawn in. Notice that the first reversing jumper lead R_1 is connected to a bottom left-hand conductor. In Fig. 15, the second section of the *A* phase has been drawn. Notice that R_2 is also connected to a bottom left-hand conductor and that A_2 is connected to a top right-hand conductor. The remainder of the diagram can be readily worked out from the information that has been given.

In Fig. 12 is shown a series-delta connection for the series-star connected winding shown in Fig. 11. The two small sketches at the bottom of Fig. 12 show two ways of changing to the delta connection. In making a delta connection it will help any winder to consider the machine as being star connected. Then make a small open-star sketch as is shown at the bottom of Fig. 12. Then when making the delta connection, all confusion as to which pair of leads connects to any one line lead, is eliminated. The winding shown in Fig. 12 is connected as is shown in the lower right-hand schematic sketch in the same figure. In both the working diagram and the schematic sketch, the end of the *A* phase, A_2 is connected to the start C_1 of the *C* phase; that is, the top conductors in slots *24* and *6* go to one line lead. The end C_2 of the *C* phase is connected to the start, B_1 of the *B* phase; that is, the top conductors in slots *10* and *20* are connected together to the second line lead. The end, B_2, of the *B* phase is connected to the start, A_1, of the *A* phase; that is, the top conductors in slots *2* and *4* are connected to the third line lead.

This winding might also have been connected series-delta in the manner shown in the schematic sketch at the lower left-hand corner of Fig. 12. In this sketch the start, A_1, of the *A* phase is connected to the finish, C_2, of the *C* phase; that is, the top conductors in slots *2* and *20* are connected to one line lead. The start, C_1 of the *C* phase is connected to the end, B_2, of the *B* phase; that is, the top conductors in slots *4* and *6* are connected to the second line lead. The start, B_1, of the *B* phase is connected to the finish, A_2, of the *A* phase; that is, the top conductors in slots *10* and *24* are connected to the third line lead thus forming the closed delta. Hence, in constructing a delta-connected winding diagram it can be seen that the first part of the procedure is the same as for the star-connected diagram. Letter the start of each phase A_1, B_1, C_1 and the finish of each phase should be lettered A_2, B_2, C_2. Then after connecting the phases together as was shown in the schematic sketches of Fig. 12, the winding should be checked for polarity. As was stated before in this article, the instantaneous polarity of the phases should be such that any two phases will lead into the winding, while the remaining phase leads out. That is, if arrows are (*Continued on page 507*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, October, 1924

Who Is Responsible for Substation Failures?

IN THE interest of continuous service, periodical inspection of the industrial substation is a matter that deserves more attention than it usually gets. When energy is purchased, the responsibility for such work naturally falls upon the power supply company; but whether inspection of substations is done by outsiders or by the maintenance organization of an industrial works, there should be a thorough understanding of what such work involves on the part of the repair staff. The essential points of electrical inspection readily occur to anyone familiar with this class of equipment, but it is always helpful when the industrial maintenance organization "plays close" to the central station engineer in this regard.

It seems to be a fact that there are poor and good methods of doing inspection work, like taking oil samples, finding out how to store transformer oil, testing lightning arresters and other apparatus, and so on. In some localities it is now the practice to make a "fine-toothed comb" inspection of industrial substations once or twice a year, in addition to weekly or even daily superficial inspections associated with cleaning floors and grounds, and preventing the accumulation of dust and dirt on gauges, meters, relays and other equipment. The determination of the proper length of the period between inspections of various types should not rest on mere chance, but should be the result of a careful study of local conditions which co-ordinates the tasks of the electrical operating and maintenance forces with the primary object of preventing service failures and accidents.

Where an industrial plant has a number of such substations, adequate records are important and a leaf may well be borrowed from the central-station book in checking up procedure. The practice of making first-hand inspection records on stiff cards and later transferring these into a log book kept in a sectional binder has much to commend it. Data can be classified in this way for quick reference and if the log book carries a schedule of the inspection work due on each substation at different dates, it will help to insure promptness in covering the installations. Opinions differ as to the wisdom of including meter readings, records of the height of oil and operating history in the condition sheets; but without branching off into this detail, the point may be made again that a systematic effort to standardize and co-ordinate such work with provision for destroying unimportant records after a year or so of service deserves the attention of maintenance men.

What Goes on the Drive Side of the Coupling?

ANSWERING the big question, "What kind of apparatus shall we install at the motor side of the mill coupling?" L. A. Umansky said in a paper presented to the Association of Iron & Steel Electrical Engineers at their annual convention at Pittsburgh, Pa., "The primary purpose of any mill is to roll steel—the more of it the better. There is no use comparing costs of several systems of electric drive without testing their effect on the mill output; the most economical drive is not the one that has the lowest cost, but the one that costs the least per ton of steel rolled. The cost of electrical equipment is only a part of the cost of the whole mill; one is truly wise who pays more for a part in order that he may save on the whole."

This is also true in selecting the form of power drive for any industrial application. How often is it the case that a makeshift drive is installed in order that use may be made of an old spare motor of the wrong speed for the application, and thus save the cost of a new motor? How often do we place an open motor in a location that demands a mill-type motor just to save the added expense of the more rugged enclosed motor? How often does one put up with a large manual controller where an automatic controller would give more convenient and speedier operation? One might go on at great length in citing such examples.

The deciding point, however, in determining a drive installation is not its first cost, nor how easily it can be maintained but—is it the most economical from the standpoint of amount of product it will produce in a given time? As Mr. Umansky says, "It is far better to spend a little more time with pencil in hand, making a complete preliminary study of the subject, than to make a rash and possibly wrong decision and then pay for it in tons of steel that might have been rolled."

What Parts to Make and What Not to

IN THE discussion of maintenance procedure at a meeting of the Association of Iron and Steel Electrical Engineers in Pittsburgh last month, a superintendent of a large plant dropped a pearl of wisdom when he said, "Don't try to be a manufacturer." By this he meant that costs and facilities to produce parts should be carefully considered before deciding to make them for repair work on standard motors.

The case of making bearing metal was cited. On this he said that although it may be known what the analysis of the metal should show, it's quite another thing to put all the ingredients together and get what you expect. This is the business of manufacturers of bearing metals and since reliability of motor service is the thing the mill expects of its repair force, it is poor

policy to gamble with the quality of bearing metal by experimentation. Such procedure is usually expensive at best. In the matter of making coils, too, without good coil-winding and pulling equipment, the cost of coils for machines other than obsolete types is worthy of thoughtful study.

Again, the substitution of materials in repair work requires more than guessing. Before a change is made in insulating materials, varnish and the like used by the original manufacturer, much experience or consultation with other repair men should be the course followed, rather than depending upon experiments with this and that material, for at best a rewind job costs money and a failure at the wrong time may increase this cost to a point where expediency and a hurry-up job are more costly than a complete new motor.

While there are exceptions to all rules based upon experience and a thorough knowledge of the work being done, it is a good plan to confine repair work in a mill or factory to that class of repairs frequently required and go to the manufacturer for the special repairs and parts that call for particular manufacturing facilities or an expert knowledge of the requirements of their machines.

The Man Who Doesn't Make Mistakes Never Does Anything

SPEAKING before the Chicago Chapter of the Society of Industrial Engineers, Guy H. Rumpf, Works Manager of Joseph T. Ryerson and Son, Inc., expressed in the following words some viewpoints regarding the authority and responsibilities of foremen that are of interest both to executives and to those who work in the ranks:

> It is not necessary for the President, General Manager or Superintendent to understand the details of each particular machine or part of production. It is, however, essential that the foreman be capable of operating every machine and doing each piece of work in order that he may demonstrate to the men, whenever necessary, that his instructions can be carried out. Men have confidence in such a foreman and produce the best results.
>
> There should be one line of authority and this should come through the foreman. A foreman is held responsible for the production of his department and in order that he may produce the results desired he must have the necessary authority. * * *
>
> A superintendent or foreman should stand for his own mistakes. He should give instructions, expecting that they will be carried out and if they do not produce the proper results he should take the blame himself. Even though the foreman or superintendent may make mistakes, as long as he does not attempt to blame the workmen or someone else reporting to him, the men will retain their confidence and respect in their superior.

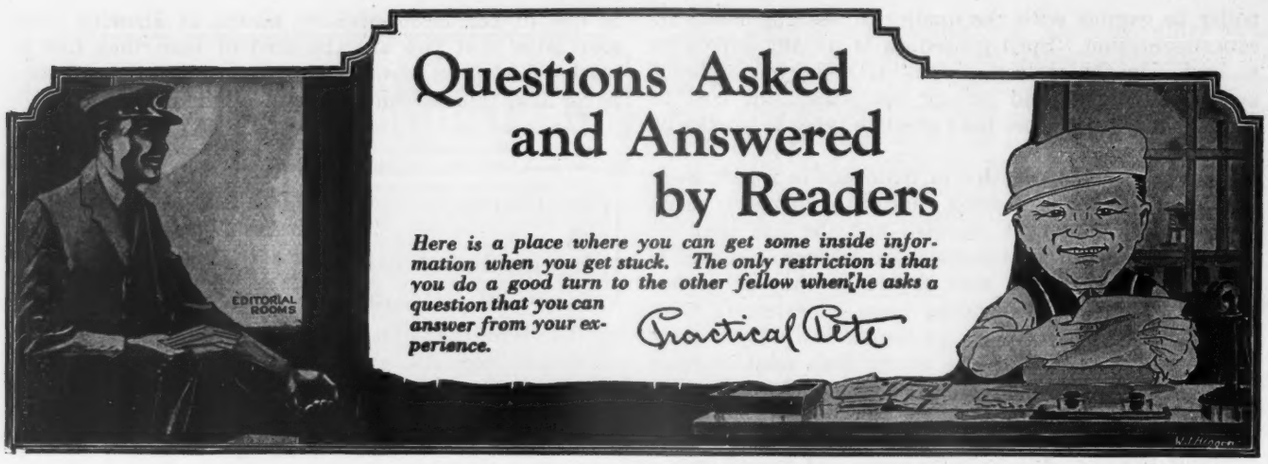
Important as these principles are in the conduct of the production departments, they are probably of even greater value in carrying on the work of the maintenance department. This department usually works under trying and unusual conditions and, particularly in emergencies, much must be left to the judgment and resourcefulness of the foremen and the individual workmen. Under such conditions, when decisions must be quickly made and carried out with perhaps only an imperfect knowledge of all of the factors that might influence the correctness of the decision, the chances of making mistakes are many. Nevertheless, it sometimes requires a good deal of moral courage on the part of foremen and of workmen to admit that a mistake has been made. Such an admission, frankly made, is one of the most effective means of showing your associates that you are the kind of man they like to work with, for the man who never makes a mistake never does much that is worth while imitating.

Job-Diaries on Maintenance Work

THE average industrial plant engineer concentrates so intently upon getting the physical side of his work done that he is often tempted to overlook the proper recording of its technical features after the time cards are completed and the vouchers initialed. Many highly competent maintenance men feel that their duty has been done when the basic cost data of a job are turned over to the accounting department. This is a natural attitude, but the trend of the times in maintenance work is towards its better organization and control from one year to another and this means capitalizing field and plant experience more thoroughly than ever before.

Any records that will keep a maintenance staff from duplicating preliminary work and investigations on new jobs from the drafting board up are essential to quick changes and repairs at the lowest possible cost. Under the stress of operation it is often necessary to push repair jobs through without slowing down the work for record preparation at the time; but after the job is completed, it is a great pity to forget it and to fail to put on paper for future use the more striking things about the task. We believe that there is a place in industry for what might be called maintenance-job diaries—books of loose-leaf type in which the details of interesting repair jobs are typed or written to provide information that will be useful in handling similar future jobs. On most maintenance work simple sketches of the methods of doing the work are required while the job is in hand. These are easily lost or destroyed if no effort is made to preserve them, particularly if they are rough "handy" drawings which do not have sufficient dignity of appearance to join the engineering department's "regular army" of tracings. Such sketches even fail to find lodgment in the engineer's personal notebook, and yet their correct filing with dimensions checked in the maintenance-job diary would save time, money and mental wear and tear if so indexed for subsequent work. Revised markings on these sketches also often indicate certain troubles that might be avoided in future work.

Along with these sketches, which could easily include wiring layouts, details of framing for portable motor test tables, sections of scaffolding and of other timbering used in supporting pipe runs, safety guard designs, etc., to mention just a few things worth recording, might go summarized cost data for particular jobs, names of men concerned and the time required to perform the work. There is scarcely any limit to the homely but intensely practical information that might find a berth in this kind of a reference book, which at very moderate expense could be transmitted to other engineers for criticism and improvement. There is no question that a lot of valuable repair job data now escapes from custody and is never recaptured after such work is done, and the maintenance-job diary would seem to be a suggestion worth trying in the interests of conserving future time, effort and expense.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Trouble Caused by Plugging Elevator Motor—Will some reader of INDUSTRIAL ENGINEER please give me some help on the following problems? (1) We have a 10-hp., 550-volt, three-phase elevator motor which is controlled by a Cutler-Hammer reversing switch. We are experiencing a good deal of trouble from blowing of fuses due to reversing the motor before the elevator comes to a full stop. This elevator has no regular operator and is used for freight service only. Has anyone had similar trouble and what is the best method of overcoming it? (2) Is it possible to wind a magnet that will lift from 10 to 25 lb. and can be operated on a 110-volt, sixty-cycle circuit? If so, please give me the winding data for 110 volts and also 550 volts.
Millbury, Mass. L. A. T.

* * * *

Removing Concrete Foundations by Blasting—We want to remove the foundation of a large engine and I should like to have the experience of other readers in removing foundations by explosives or in other ways. How can I keep down the concrete dust while drilling the foundation? If we blast the foundation how can I keep pieces from flying and damaging nearby machines? Will it be necessary to take the windows out? What explosive works best and how much should be used for a shot? I shall appreciate any suggestions you can give me.
Detroit, Mich. A. H.

* * * *

How Does the Lundell Motor Operate?—Can some reader of INDUSTRIAL ENGINEER give me a simple explanation of the theory of operation of the Lundell d.c. motor made by the Sprague Electric Co.? This motor has only one field coil (either series or shunt) which is placed in the frame in such a position that the armature rotates in the center of the coil. In other words, the field coil is wound around the armature.

I should like to know how and where the magnetic field poles are formed.
Philadelphia, Pa. C. F. S.

* * * *

Deterioration of Glass in Skylight—We have found serious deterioration of the glass in some skylights and wish to know if any reader has had a similar experience and can advise us what to do.

There are two machine rooms, one built in 1916 and the other in 1920, partly lighted by puttyless skylights glazed with ¼-in. wire glass. The glass in the first room shows no deterioration, beyond an occasional crack. In the skylights of the other room there are fine, interlacing cracks which in places expand into large patches. A skylight close to a relief valve, from which hot water sometimes drips, shows the most serious deterioration and in places has holes 2 in. to 3 in. in diameter. All of the lights are subjected to a temperature of 115-125 deg. F., from dryers below them, but none except the one mentioned above can be reached by anything except rain and snow. The skylights over the other machine room have been subjected for twice as long a time to identical conditions and are in practically perfect shape. Can anyone suggest the cause and a possible remedy for this condition?
New Haven, Conn. H. D. F.

* * * *

Priming Coat for Plaster and Brickwork—Will some reader of INDUSTRIAL ENGINEER please tell me what kind of sizing or priming coat should be applied when brickwork and plaster walls are being painted for the first time? We wish to paint the walls and ceilings of both office and shop and I understand that some preliminary treatment is necessary before the finishing coats of paint are applied.
Cleveland, Ohio. L. McC.

* * * *

Method of Checking Alignment of Lineshafting—We have two long, and several shorter lengths of lineshafting which I know is somewhat out of line, probably due to settling of the building. I shall appreciate it very much if someone will give me a simple method of lining up these shafts accurately in the hangers, so as to reduce friction in the hanger bearings.
Milwaukee, Wis. S. V. B.

Answers Received To Questions Asked

Trouble with Traveling Cranes—I am having trouble with two traveling cranes which run on the same track and are used for loading and unloading stone in a mill. One crane is rated at 20 tons and the other at 30 tons. Each crane has two slip-ring motors of about 20-hp. rating, which operate at 220 volts, sixty cycles and are controlled by General Electric starters. When both cranes are in operation the hookers on the ground get a shock every time they touch the chains which are used to carry the load. When either one of the cranes is idle, the men do not get a shock. I have tested out all circuits with a magneto and was not able to find any indications of trouble. I shall appreciate it very much if any of the readers of INDUSTRIAL ENGINEER can tell me how to find this trouble.
Bloomington, Ind. H. M.

In reply to H. M.'s inquiry in the August issue, it would seem that his cranes must be in a frame building, or the track is on a frame structure, and that there is a leak in the insulation of the motors sufficient, when both motors are running, to shock the men when they take hold of the hooks or chains, as this is the only path for the leaking current to get to the ground. I believe that if he will bond the rails and ground them well he will overcome this trouble.

This leak may be caused by the stator windings being oil-soaked sufficiently to make them conductive, although the leakage may not be sufficient to shock anyone when only one crane is running. Trouble from this cause may be cured by taking the motors apart, cleaning them thoroughly and baking the stator from 24 to 48 hr. in an oven at not less than 200 deg. F. and then applying a coat of a high-grade, air-drying varnish. I would advise a thorough inspection and cleaning of the motors by disassembling them. I have been able to overcome a great many troubles in motors by so doing.

I hope these suggestions will be of some help to H. M.

Chief Electrician,
Knoxville, Iron Co.,
Knoxville, Tenn. W. P. AMANNS.

* * * *

The conditions stated in H. M.'s question in the August issue, suggest the existence of high-resistance grounds on two legs, one or both of the grounds being on the motor side of the controller. Were the faults of the order of a short circuit, the magneto would have indicated the condition. Even low-resistance grounds would not blow fuses, assuming the crane construction, including the rails, to represent high resistance and the connection between the construction and the earth, on which the hookers stand, to be a poor one. The mere shocking of the hookers indicates that the current path, including his body, must have considerable resistance. As shocks are obtainable only when both controllers are on an operating notch, it might be enlightening to measure the insulation resistance of the motors and controllers to their frames. Charred insulation or accumulations of copper dust or carbon dust would admit current sufficient to cause a shock. If H. M. has no high voltage with which to test the break-down point of the insulations, the only alternative appears to be a thorough cleaning and overhauling accompanied by inspection. The removal of only one of the fault grounds would save the hookers further discomfort, but the removing of both is desirable because the existence of one invites the occurrence of another.
Brooklyn, N. Y. J. A. HORTON.

Methods of Repairing Wooden Floors—We have found that the wooden floors in the trucking aisles and particularly at corners where trucks are turned, wear more rapidly than the remainder of the floor. I would like to know the experience of some of the other readers of INDUSTRIAL ENGINEER in making repairs for these sections of the floors. Also, we would like to know whether our readers favor flooring laid parallel to the line of trucking, crossways, or on a diagonal.

Monmouth, Ill. J. H.

In answer to J. H.'s question in the July issue, wooden floors laid lengthwise to the line of travel are renewed more easily and cheaply than when laid either crosswise or diagonally, because in the former case every one of the boards will have been worn its full length; in the other two cases they are still good at the ends, and if they are to be salvaged, require more time for renewal.

Often a floor may be good enough outside of the trucking runway, and needs to be renewed only where it is very badly worn; the lengthwise arrangement makes it easier to do this.

Hard, thick maple flooring is the best and most economical in the end; of course, the length of time it will last depends upon the traffic. Rubber tires on all heavy trucks, such as electric tractors, etc., save wear on the flooring and the smooth surface saves the tires; together these make a neat and practical combination.

New Britain, Conn. H. S. RICH.

* * * *

Card System for Miscellaneous Power Drive Equipment—The only storage space we have for miscellaneous pulleys, shafting hangers and similar parts is some distance from the room which serves as the repair shop and headquarters of the maintenance department. As we now have no system of keeping track of this material one of the men must go and search through it whenever anything is needed. I should like to know if any reader has worked out a card system that we could use to tell what we have on hand.

Kansas City, Kan. H. L. G.

Referring to H. L. G.'s question in the June issue, I have been up against the same conditions myself, and have worked out a labor and time saving card system which may be of use to him.

I use cards 6 in. long by 5 in. wide, which are filed in a small box.

Cutting a piece ¾ in. wide and two-thirds the distance across the card leaves a margin above the rest of the card on which certain data can be kept. In the case of pulleys I put down the diameter, as this is usually the most important dimension. A pulley can be used even if the face is a little wide; also the bore can in most cases either be bushed or bored to fit the shaft, but the diameter can not very easily be changed.

For hangers I place the bore of the bearing in the margin.

Complete data for each pulley is entered on the body of the card. This data includes the condition, whether new or used, whether split-steel bushing or solid, from what machine taken off and any other facts that may be of use.

When a pulley is taken from stock note is also made on the card of its new location. Oftentimes a pulley on a very important machine will break or become useless through wear and there is no spare in stock. A glance through the card file may show one on another machine whose production is not so important and this pulley may be removed, saving the time of measuring different pulleys in trying to locate one that can be used.

Pulleys are stored on a rack made by nailing together two pieces of 2-in. by 6-in. timbers, and fastening them to a side wall. Pieces of 2-in. pipe, driven into holes bored at a slight angle into these timbers, support the pulleys. A wooden plug was driven into the ends of the pipes and sawed off flush. A piece of tin with a number stamped on it, was nailed to each plug, thus identifying the pipes.

When storing the pulleys, several can be placed on one pipe, depending on the weight and size. A separate card is used for each pulley or hanger, but all cards having pulleys or hangers listed on the same pipe have the pipe number in one corner of the card away from the rest of the data, so that it may be easily read.

My experience has proven that a card file on anything stored will soon pay for itself, and at present I am making one for pinions in storage.

Chief Electrician, Wyckoff Drawn Steel Co., Ambridge, Pa. N. H. CASE.

* * * *

Replying to H. L. G. in the June issue, we use the card shown in the illustration for keeping a record of miscellaneous pulleys. These cards, which are standard 3-in. by 5-in. index cards, are made out by the head of the maintenance department and kept in his files. If there is on hand only one pulley of a particular size, a new card is made out when the pulley is sent to the stockroom. When the pulley is taken out of stock, the card is destroyed.

If there is more than one pulley of the same size on hand, the number shown on the card is altered each time a pulley is put into or removed from stock. I believe this card could be improved by adding the words Flat and Crown, one of which could be crossed out as needed.

Guilford, Me. DONALD MAXFIELD.

* * * *

Testing Large D.C. Generators for Short-Circuits—Will some one give me a good, practical method of testing for short circuits, large d.c. generators and motors, especially those having equalizers or cross connections? I have in mind machines of 1,000-hp. rating and over. In the various articles on testing which I have read, I have failed to find any mention of these connections and should like to know the procedure when testing out a machine which has them.

Ottawa, Canada. S. J.

In answer to S. J.'s question in the June issue, I use a lampbank and a millivoltmeter with a low reading scale, or an ammeter without the shunt and read only two bars at a time by touching both the line leads and the millivoltmeter leads to these two bars. Just enough lamps should be used in the bank to give a good reading, say, at least one-quarter of the scale. When employing this method of testing, you can disregard the equalizer connections.

When small armatures with equalizer connections are being tested, it is very important that the line leads be always placed on the equalizer connection. Otherwise, you will obtain different readings as you progress around the armature. Never try to test an armature with equalizer connections by a so-called buck or testing transformer, as the equalizers will act as a short circuit, giving in effect the closed secondary of a transformer and the armature may be damaged.

NICHOLAS J. WEISS.

West New York, N. J.

* * * *

From S. J.'s question in the June issue I assume that he is principally interested in testing for short circuits in the armatures of large d.c. generators, although it might be interpreted to include field tests.

The field windings, or rather the poles, may be tested by sending about 25 per cent of normal current through them, supplied from a steady source, and taking voltage readings across each field pole winding. A variable resistance may be found useful in keep-

Record card for keeping track of the number and types of spare pulleys in stock.

MAKER	DODGE MFG. CO.
Style	"STANDARD" IRON SPLIT.
Diameter	29" Face 4" CROWN Bore 3 7/16"
Keyway	Setscrews 2 - 5/8"
No. on hand	6
Location	STOCKROOM.
Remarks	OLD LOOM DRIVE PULLEYS.

ing the current at the same value throughout the test. Any marked difference in the voltage reading of one winding below the others may denote a partially short-circuited condition. The readings should be taken as rapidly as possible in order to avoid any error due to change of resistance from heating. A low-reading voltmeter should be employed and the field current kept as low as possible, or just sufficient to give a deflection of approximately one-half the instrument scale when the reading is taken across the field. It is very desirable that there be kept on hand data from the manufacturer giving the individual pole or total field resistance at some definite temperature, to which an actual test result may be corrected for comparison.

The true armature resistance of large d.c. machines with equalizer or equi-potential connections cannot be obtained so long as these connections are made to the winding. It is only possible to measure this resistance by disconnecting all the equalizer rings. It is imperative that there be on file comparison data from the manufacturer, giving the resistance of the winding as made in the shop at some definite temperature before the equalizer rings were connected. Probably the best way to test for short circuits in armature coils is by the "bar-to-bar" method. A low-voltage source of current, preferably a storage battery, is connected through a variable resistance of the carbon compression type, to adjacent bars and the drop of potential taken across these bars at equal values of current. This process is repeated until all bars have been tested. A reading which is very much lower than the others, or a zero reading, will indicate a short-circuited or partially short-circuited coil.

When testing for armature short circuits one of the greatest practical difficulties lies in obtaining reliable readings, owing to the very low resistance. It is impossible to obtain satisfactory results unless the voltmeter contacts are very firm and make a rigid, positive contact with the bars, and the use of contacts made of other material than the bars may cause an appreciable error. It is also difficult to obtain a readable voltmeter deflection at times, unless a very high capacity source of current is available. One of the largest manufacturing companies in this country has established the practice of rarely measuring the resistance of an armature after the latter has left the armature department, because of the difficulty of making such tests.

In routine repair shop work, short circuits in armatures can readily be detected by moving over the core another core built up of laminated iron and having a winding on it which is fed from an a.c. source. This test core is built up so as to have the same arc as the armature under test and can, therefore, be hung over it and close to it. Adjusting the test core and applying the a.c. current, the d.c. armature winding will act as the secondary of a transformer and any short circuits will be manifested by severe smoking. Obviously this procedure is more applicable to a shop where many armatures of the same size can be tested, but it can be used without much labor or expense under almost any conditions.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

S. J. asks in the June issue for a method of testing large armatures for short circuits. One of the best methods to use is known as the bar-to-bar, or drop-of-potential test. In applying this test a steady current from a 110-volt line is sent through the armature from two opposite sides of the commutator. Readings of the potential drop between two adjacent commutator bars are taken on a millivoltmeter. A lampbank is inserted in the supply circuit and is adjusted until an easily-readable deflection of the millivoltmeter is obtained when its leads are touched to two adjoining bars, as shown in the illustration. In this, (C) is a fiber block holding the contact points, which should be spaced to rest on adjoining bars. Before starting the test it is advisable to take a reading at several different points, in order to get the average deflection, although in the case of good coils there is very little difference in their deflection.

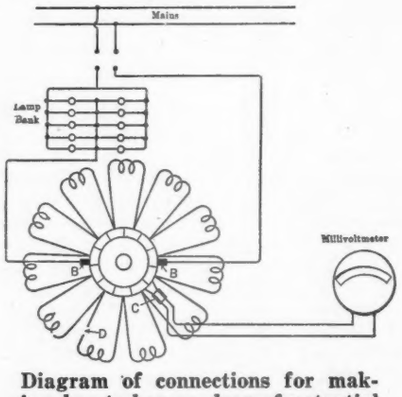


Diagram of connections for making bar-to-bar or drop-of-potential test on direct-current armatures.

The next step is to go all around the commutator, touching the contact points to each pair of bars in turn. If a short-circuited coil is encountered there will be little or no deflection of the millivoltmeter pointer, as there will be almost no drop through the coil.

This test can also be used to locate certain other defects in armature windings. For example, one type of crossed coil leads will be indicated by a deflection about twice as large as normal. Open-circuited coils or poorly-soldered leads are shown by a high reading.

Cedar Rapids, Iowa. JOHN GRIFFIN.

* * * *

In reply to S. J.'s question in the June issue, a rapid method of locating a short circuit in an armature without disconnecting any of the wires from the commutator is by the use of the bar-to-bar test. This test can be applied to any armatures with any style of connections, for there will be the same drop of potential between any two adjacent segments, no matter which scheme of connections is used.

In carrying out this test a steady current taken from a 110-volt circuit should be sent through the armature at opposite sides of the commutator. The brushes used should be just wide enough to cover one bar. A lampbank should be used in the supply circuit and so adjusted that a readable deflection is obtained when the two leads of a millivoltmeter are touched to adjoining commutator bars. The deflection of the millivoltmeter will depend on the difference of potential between the bars.

The contact points are touched to each pair of bars and the deflection of the millivoltmeter noted. If all of the coils are good practically the same deflection will be obtained all around the commutator. When the contact points are touched to the bars to which a short-circuited coil is connected there will be very little or no movement of the millivoltmeter needle, as there will be little or no drop through this coil.

Woodward, Okla. H. J. ACHEE.

* * * *

Construction of Pipe Rails and Guards—We have found it necessary to make some pipe rail guards to extend alongside some of our machines to prevent trucks from getting too close to them and also to provide a free aisle alongside the machines for the operators. As we wish to make these easily removable, I wonder if some of the readers of INDUSTRIAL ENGINEER could offer any suggestions as to how these can be made sectional, the size of pipe to use, kind of fittings, construction of floor sockets, the span between supports, the most convenient length of sections and methods of connecting the sections.

Peoria, Ill. G. G. H.

Replying to G. G. H. in the July issue, I have used the following schemes in connection with removable guard rails, and have found them very satisfactory.

The first question to decide is the size of pipe to be used in making the rails. For ordinary purposes a rail made of 1½-in. pipe is strong and heavy enough; it makes a neat job and is not expensive. The length, height, number of bars and so on will depend on the conditions.

If the railing is to be set up on a wood floor a sufficient number of sockets should be made up from pieces of 2-in. pipe, assuming that the rail is made from 1½-in. pipe. These pieces should be cut 10 in. long and threaded at both ends. A pipe cap should be screwed on one end and a railing flange on the other. Holes should be cut in the floor at the points where the uprights of the railing will be erected. These holes should be accurately spaced with respect to the length of the rail, so that the latter can easily be set up and taken down. Also, it is desirable not to make the holes any larger than necessary, in order to give a firmer support for the sockets and lessen the danger of splitting the wood when the floor flanges are screwed down. Bolts, lag screws or wood screws may be used for this purpose.

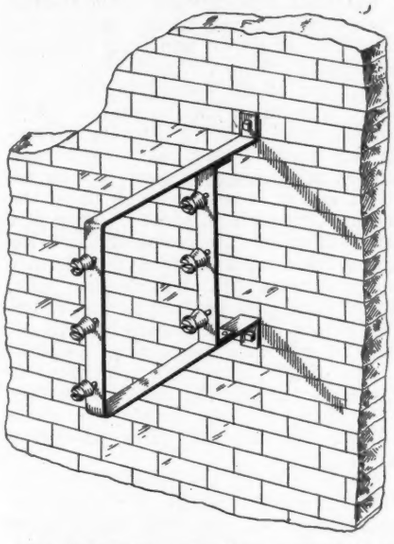
If the railing is to be installed in concrete floors, a much neater job can be done as follows: Cut holes in the floor about 1 ft. deep and 3 in. or 4 in. in diameter. Pieces of pipe about 10 in. long should be placed in these holes, accurately spaced and lined up flush with the level of the floor and cemented in place. These sockets will be practically invisible when the railing is taken down.

When railing is to be removed in sections this can be arranged by making the sections shorter and leaving the desired space between them, or round, oak sliding bars may be used. If wood sliding bars are used they must be made to fit the pipe so as to slide in and out easily and all burrs on the inside of the pipe must be removed by filing, to prevent splintering of the bars.

Boston, Mass. F. J. H. KRAUSE.

* * * *

Will These Brackets Cause Trouble?—I am sending a sketch of an iron bracket which is to be used for supporting two sets of feeders for a three-phase, 550-volt system. Considering that the brackets are made entirely of iron, I should like to know if there would be



any inductive or other action if 20 or 25 of these brackets were used. If so, could it be eliminated by making the brackets of brass or copper? Will someone please advise me what to do?

Hastings-on-Hudson, N. Y. S. S.

In the July issue S. S. shows a sketch of an iron fixture which he contemplates using to support two sets of feeders. I can see no reason for not using this fixture, as feeders supported on the cross members will be in the same situation as if run through a short piece of large diameter conduit, and those on the outside of the fixture the same as if supported on a beam or girder, as is commonly done behind switchboards and in other station work.

Denver, Colo. JOHN E. HOLTMAN.

* * * *

Referring to the inquiry by S. S. in the July issue, the iron bracket shown may be considered as an iron conduit of large diameter. I know of one instance where single-phase current carried in conduit caused the latter to become so hot that you could not place your hand on it, and this overheating was remedied by carrying three-phase current in each conduit, instead of single-phase. Inasmuch as S. S. intends to carry three-phase energy on each bracket I am sure that he need not worry about any possible inductive effect which will cause heating. However, if his feeders are to carry heavy currents the bracket parts and insulator pins must be securely fastened together and the bracket have a good bearing and be tightly bolted to the wall; otherwise there may be produced a decided humming noise. If the above precautions are taken this humming will be minimized or entirely eliminated.

Further evidence that S. S. need not anticipate any undesirable effects from this type of construction lies in the fact that large feeders, carrying heavy currents, of the power companies' lines are carried in underground conduits and through tunnels on iron brackets and hangers which are more or less similar in design to the one he contemplates using.

Oakland, Calif. S. H. SAMUELS.

* * * *

Answering S. S. in the July issue, the metal in the brackets would cause no harmful effects on a 550-volt system, but if the insulators are exposed to the weather they should be mounted vertically, and not horizontally, as ice will form inside of the petticoat bells and break them open, thus allowing the conductors to ground on the sharp edges of the brackets. For out-of-door use the conductors must be at least 12 in. apart and the first one ought to be 1 ft. from the wall.

Galvanized, malleable-iron pins and bolts should be used, and mica insulators are the most durable, as both glass and porcelain will crack from temperature extremes and line strain. For indoor use, glass is good enough.

The brackets should be made of ½-in. by 2-in. iron, well bolted together, and either bolted or lagged to the walls by ⅝-in. bolts 5 in. or 6 in. long. If heavy lines are to be carried, bolts through the wall would be far safer. It must be recalled that during the winter the line must stand the strain of ice, snow and heavy winds, all of which tend to loosen the fastenings.

New Britain, Conn. H. S. RICH.

* * * *

In answer to the question by S. S. in the July issue, it is assumed from the sketch that one circuit is mounted on the outside and one on the inside of the bracket or, in other words, so that all three conductors of one circuit are inclosed by the strap-iron support.

There is no reason why the method of construction indicated will not be quite satisfactory, since the three wires of the one circuit are all located inside of the magnetic loop. Theoretically, there may possibly be some slight inductive effect due to the arrangement of the conductors in a horizontal plane, but even with unbalanced currents in the different conductors this effect will be small if only twenty or twenty-five brackets are installed and the circuit is not of any considerable length.

The writer has in mind a specific instance in his experience where it was necessary to carry a three-phase circuit having a maximum current of 1,100 amp. at 60 cycles through a large plate girder. This was done by cutting through the girder a triangular hole of sufficient size to carry the conductors, which were placed in insulating tubes. Absolutely no heating or other trouble has developed after more than five years of operation.

There have been specific cases where heating has developed but these are usually limited to instances where very heavy currents are carried, as in electric furnace work.

In any event it would be unnecessary to make the brackets entirely of brass or copper. By simply breaking the magnetic circuit and inserting a copper connecting piece, thereby placing an air gap in it, there would be practically no reason for any noticeable inductive effect. C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp., New York, N. Y.

* * * *

In reply to S. S.'s question in the July issue, we are using practically the same method of carrying three three-phase circuits on an industrial job. In this case No. 4 conductors are used and no trouble has been experienced in the three years this installation has been in service. I should say, therefore, that S. S. would be perfectly safe in using the type of bracket shown with his question.

Woodward, Okla. H. J. ACHEE.

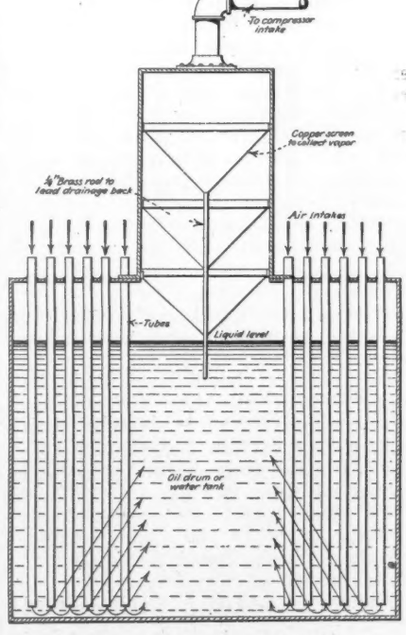
* * * *

Air Filter for Intake of Air Compressor—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick.

Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?

Norfolk, Va. W. B. E.

With reference to W. B. E.'s question in a late issue, I would suggest that he procure an old, steel oil or water tank of about 75-bbl. capacity and weld in place a large number of tubes, as shown in the illustration. These tubes may be suitable lengths of pipe and



Suggested method of filtering intake air for air compressor by passing it through water or oil.

should extend to within 2 or 3 in. of the bottom of the tank, which should be partly filled with water, or oil if it will be exposed to low temperatures. The upper end of the tubes should, of course, be open so that they will serve to conduct the incoming air through the liquid in the tank and thus free it from dust and other foreign matter. Without knowing the size of the compressor in question, it is not possible to give the size and number of tubes, but I do not believe that they should be larger than 1 in. in diameter. W. B. E. should put in enough tubes to make their aggregate area somewhat larger than the area of the compressor intake. The more tubes that can be conveniently placed in the tank the better, as the resistance to the passage of the air will be reduced and less vapor will be carried over.

It would also be necessary or advisable to mount on top of the tank, over the manhole, a dome which should serve as the outlet for the filtered air and be connected to the air intake of the compressor. This dome should be built of ¼-in. boiler plate and made air tight. It should contain fine wire screen which would serve to stop vapor and liquid particles from being drawn over into the compressor.

I believe a device of this sort would solve W. B. E.'s problem, providing that he constructs one which will be large enough to supply the compressors without too much liquid being drawn over. In any event, I hope that this suggestion will be of some help to him.

Marietta, Ohio. E. L. WAY.

* * * *

Moisture-Proofing Treatment For Motors in Pulp Mills—I wish some of the readers of INDUSTRIAL ENGINEER would tell me what method or treatment they use for keeping moisture out of the windings of motors and other electrical equipment which is located in very damp places, particularly in paper pulp mills. I shall be very grateful for any information you can give me.

Temiskaming, Que., Can. J. H. S.

Answering J. H. S. in the July issue, to moisture-proof motors, either d.c. or a.c. types, first disassemble to such an extent that all windings are within reach; then clean out all dust, etc., preferably with dry compressed air. Put all parts carrying windings in a very warm place, as in an oven, or on a boiler top, and thoroughly dry out all traces of moisture. Then coat the fields or the stator windings with P. & B. or some other good standard armature varnish, being sure to get it into all crevices. If either the armature or the rotor cannot be dipped bodily, spray or brush the varnish on well and in between all leads.

All windings should then again be subjected to a mild heat for at least 24 hr. One thorough coating with good quality varnish generally is sufficient, but for more certain protection against moisture two coats are better.

The chief consideration is that all windings must be thoroughly coated, and the varnish should be fairly dry before the motor is put to work.

Starting compensators can be cleaned and heated without much trouble, and then well coated with varnish, especially at coil windings and terminals. Shellac does not answer the purpose as well as do especially-prepared armature varnishes. If the latter are too thick, do not thin down too much, as certain parts, like tape windings, mica insulation under the windings, etc., may be loosened by the softening effect of the thinner.

Windings which are well varnished before being put to work and then treated again similarly after a few weeks, or whenever overhauling is done, will be well-night moistureproof.

Induction motors so treated have been operated out-of-doors on coal hoists and cranes the year 'round, with no breakdowns.

New Britain, Conn. H. S. RICH.

* * * *

In answer to the question asked by J. H. S. in the July issue, there is no way of keeping water and moisture out of most of the motors because the surrounding air is saturated with moisture. Most of the trouble is caused by water being splashed on the motors when cleaning up. Machine room bosses and superintendents are always willing to co-operate with the electrical department in trying to keep the motors as dry as possible, but the help that does the cleaning usually changes frequently. About the time that you think the cleaning crew is educated to the dangers of getting water on electrical equipment you come in some morning and find a bright young fellow washing spider webs off the ceiling over the motors. He thinks he is doing you a favor by washing off the dust. So it is a question of how to make motor windings resist water and moisture.

After a thorough investigation and study of ways of treating motor windings the following method was adopted. It has been found very satisfactory, as I have not rewound a single motor in the six years since I started this treatment.

When a motor is brought in to be rewound, the type of connection, coil pitch, size of wire and other data are taken when the stator is stripped. In particular we note whether the wires fit very tightly or loosely in the slots, to see if the thickness of the slot insulation can be increased. Whenever possible the coils are made of double-cotton-covered, enameled magnet wire. The thickness of the slot insulation depends on the size of the motors and the amount of room in the slots. Generally one cell of 0.012-in. or 0.016-in. fish-paper is put in the slot next to the iron and reaches up to where the bottom of the wedge will be. One cell of 0.015-in. empire cloth, of the same size, comes next and another cell of 0.007 or 0.009-in. fishpaper is placed inside of the empire cloth cell and extends about ¾ in. above the top of the slots to protect the wires when they are placed in the slot. Another fishpaper cell of the same thickness is placed between the top and bottom sides of the coils. The coils are taped with one layer of 0.010-in. cotton tape, ½ in. to 1 in wide, depending on the size of the coils, lapped half-way. Two thicknesses of 0.015-in. empire cloth are placed between phase coils.

When the motor is completely rewound it is given an insulation test of 1,100 volts to ground, with ten 110-volt lamps in series, for about one minute. It is then assembled and run for about an hour or so to make sure that the connections are right and that there are no short-circuited coils. Following this, the motor is taken apart and the stator placed in the oven for four or five hours at a temperature of about 75 deg. C. This heating helps the varnish to penetrate the coils. If they are cold the varnish will be chilled and tend to thicken, thus preventing it from reaching all parts of the coils and sealing up portions of the slots that the coils do not fill up.

By means of a chain block the stator is then lowered upside down into a tank of black, elastic baking varnish, made by the Sterling Varnish Co., until all of the coils are covered. The stator is allowed to remain in the varnish for about two hours, or until all bubbling has ceased. This insures thorough penetration of the coils. The stator is then raised out of the varnish and left hanging until it stops dripping. During this period I keep the varnish tank covered with heavy paper or canvas, with a slot in it large enough to let the chain go through, in order to keep dirt out. Keeping the tank covered also helps to prevent evaporation of the thinner and facilitates draining of the coils, as the varnish is not chilled and thickened before it has a chance to drip off. The stator is then baked at a temperature of about 100 deg. C. for twelve to fifteen hours. We dip and bake stators three times and afterwards give them a brush coat of black, quick air-drying paint.

The treatment described above applies to stators where the slots are semi-closed and the coils taped after they are in place. I have so few failures in the larger sizes of motors, in which the coils are made of square wire and taped before winding, that I do not attempt to make the coils. They are purchased from the manufacturer and after the stator is wound it is dipped and baked twice, in order to fill up the slots and insulate the end connections.

MARIN PHILLIPS.

Electrical Superintendent,
Interlake Pulp and Paper Co.,
Appleton, Wis.

* * * *

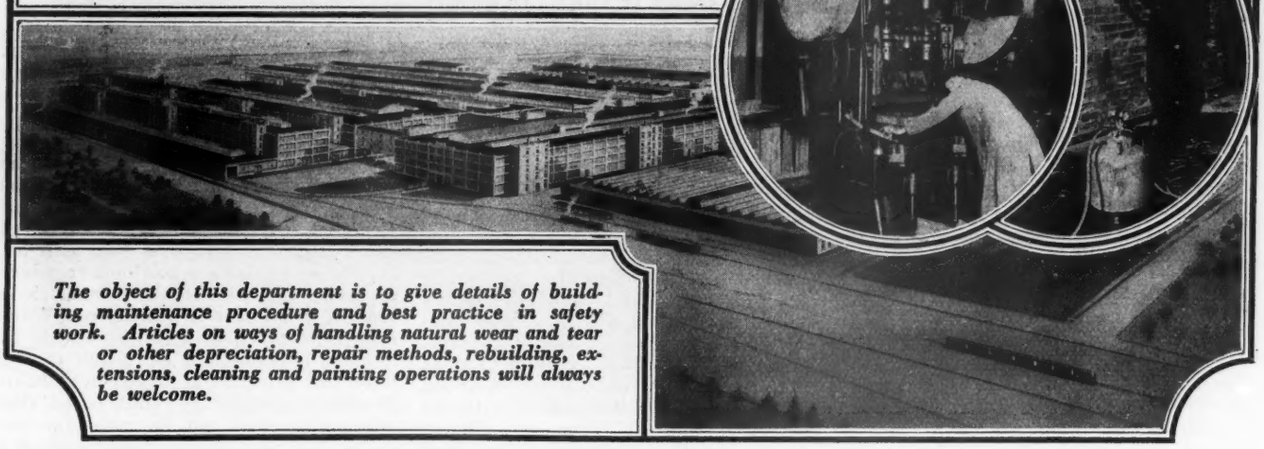
Connecting Extension Bell to Telephone—I shall appreciate it very much if readers will give me some information on the following problem. In our engine room we have a telephone which operates from the city system, through our own switchboard. When the engines are running it is impossible to hear the bell ring unless some one is standing close by the telephone. I wish, therefore, to install a large alarm or extension bell. How should this be connected? What voltage is used to ring the telephone bell? What voltage and type of bell should I use? Is it necessary to use a relay for this bell; if so, what type is preferable? Please give me a wiring diagram showing how this bell should be connected.

Chicago, Ill. W. A. B.

In answer to W. A. B. in the September issue, I believe he will find that the telephone companies do not permit subscribers to connect extension bells or any other devices to their lines or to any lines connecting with the companies' lines. Upon application and the payment of a small installation charge, the telephone companies will, however, put in any desired size of extension bell.

Walkerville, Ont., Can. R. B. TURNER.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Reducing Fire Hazards from Dipping Tanks

PRACTICALLY every modern factory employs some sort of dipping, quenching, or spraying operation which uses inflammable liquids and thereby creates a special fire hazard.

The automobile industry furnishes an excellent example of the dipping process. Here are found large dipping tanks in connection with especially-designed mechanical conveyor systems and baking ovens.

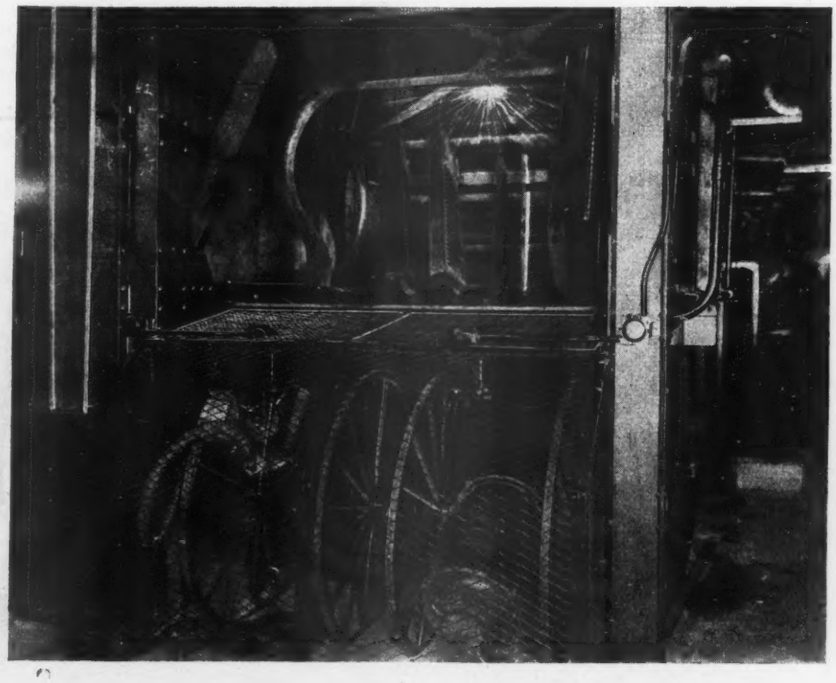
Closely allied to the dipping tank as a fire hazard is the quenching tank, for hardening and tempering the many varieties of alloyed steel needed in the manufacture of modern machine parts. Most of these processes involve the use of tanks holding highly inflammable compounds. The more inflammable mixtures used contain naphtha, benzine, gasoline, and benzol. Of a less hazardous nature, but at the same time extremely dangerous, are mixtures containing turpentine, kerosene, linseed oil, heated asphaltum, paraffine, and quenching oil.

The Danger.—Dip tanks with their drain boards, quenching tanks, saturating tanks and the like, are a potential source of extraordinary fire danger which no plant manager can afford to underestimate. An effort to speed up production, an over-heated oven, a defect in electrical equipment, an open flame carelessly brought within the zone of the highly inflammable vapor from the dip tank, may render useless all the arduous efforts of the plant's designing and operating engineers to maintain continuous production. Once started, a fire will spread if it is not controlled by adequate fire fighting equipment of a type suitable for the particular risk.

Need for Fire Prevention.—The need for making every reasonable effort to prevent fires is self-evident, but unfortunately it is often overlooked. Fire prevention deserves very serious consideration in every phase of manufacturing, whether it be design, construction, operation, or maintenance. Practically every industrial fire furnishes lessons in fire prevention which can be applied to hundreds of industries with considerable advantage. There are certain special precautions which will help to prevent fires in and around dip tanks, quenching tanks and so on.

Static Electricity.—One of the most common causes of fires, and one of the most difficult yet important to guard against, is static electricity. This factor has lately been the subject of considerable discussion among fire protection engineers who realize its significance, especially under conditions in which inflammable and explosive vapors are present. The charge of static electricity, which is such a potential danger, arises from many causes, the principal one being friction between two bodies one of which is a poor conductor of electricity and not properly grounded.

An excellent example is found in connection with the use of leather belting, where it is almost impossible to eliminate the accumulation of static



A new method of protecting paint and japan dipping hazards in an automobile factory.

It has always been difficult to protect an open dipping tank from fire hazards. This difficulty has been increased by the use of conveyors for dipping and drying japan, paint, enamel and other similar work. This dipping tank is protected by two 40 gal. Foamite engines which are connected to a special actuator above the tank. This actuator is connected by a hollow tube to a compensator. A rise in temperature of over 15 deg. per min. increases the pressure in the actuator and transmits it to the release which tips the engine and discharges the Foamite, which is a frothy mixture, both above the tank and on the side (not shown here) to smother out the fire.

charges caused by friction between belts and pulleys. For this reason, it is highly important to remove all leather belting from close proximity to inflammable liquids, as the existence of the static charge carries with it the danger of an electric spark jumping from the belt to another body, such as a dip tank, having a different electric potential. To reduce the danger of static to a minimum, all shafting should be definitely grounded at either end. The principle of grounding should be carried out in the case of all apparatus where static charges are likely to be generated. An effective method of grounding is to bind or solder to the apparatus a copper wire which in turn is securely soldered to the water piping system in the factory. For desirable strength, the copper wire should not be smaller than No. 6 B. & S. gage.

Mixing aluminum bronze with belt dressing and applying it to the inside and outside belt surfaces will form a fairly good conductor between the grounded pulleys.

Ventilation.—Adequate ventilation is very important in all risks where inflammable vapors are involved. As these vapors are usually heavier than air and therefore tend to settle to the floor, the ventilating system must be designed with intakes near the floor level. In processes which give off warm vapors, the ventilating system should make provision for the rising of these vapors to the ceiling of the room. Natural ventilation is always to be preferred to artificial where it can be efficiently applied.

Construction.—Dip tanks should be isolated in separate rooms of incombustible construction. Where the manufacturing operation requires their location in the same rooms with baking ovens or similar equipment, special precaution should be taken to reduce the fire danger to a minimum.

The storage of reserve supplies of dipping liquid should be located at a safe place outside of the room containing the dip tanks. Draw-off connections should be constructed which can operate automatically to remove the contents of the dip tanks when not in use, or at time of fire.

Electrical Equipment.—All electrical equipment should be strictly in accordance with the National Electrical Code and approved by a proper authority. This applies not only to the original installation, but to later extensions as well. Cut-outs, switches, motors, and similar equipment should not be installed in the same room with the dip tanks. Where this is not practicable, special safeguards should be provided, such as spark-proof motors and the enclosure of cut-outs, switches, and similar equipment, in incombustible cabinets. All wiring should be enclosed in steel conduits, and pendant lamps should be provided with approved flexible cord, free from contact with pipe, machinery, and other fixtures. Lamps of portable type should be equipped with approved reinforced cord to insure protection against abrasion. Heavy guards should be provided for such lamps.

Spray Booths.—The application of paint, varnish, lacquer, and similar coatings by spraying with an air brush or direct pressure has come into extensive use, and with it a rather bad fire record. This process should be conducted only in a well-ventilated and protected spray booth. Most fires in spray booths result from fans and motors used for ventilating the booth, from lamps and other electric devices capable of producing sparks, and from the cleaning of the booths with highly inflammable solvents.

[This discussion of the hazards of dipping and suggestions on overcoming them, which should be known by every industrial man responsible for the conditions surrounding dipping hazards, is taken from recent literature issued by the Foamite-Childs Corp., Utica, N. Y.]

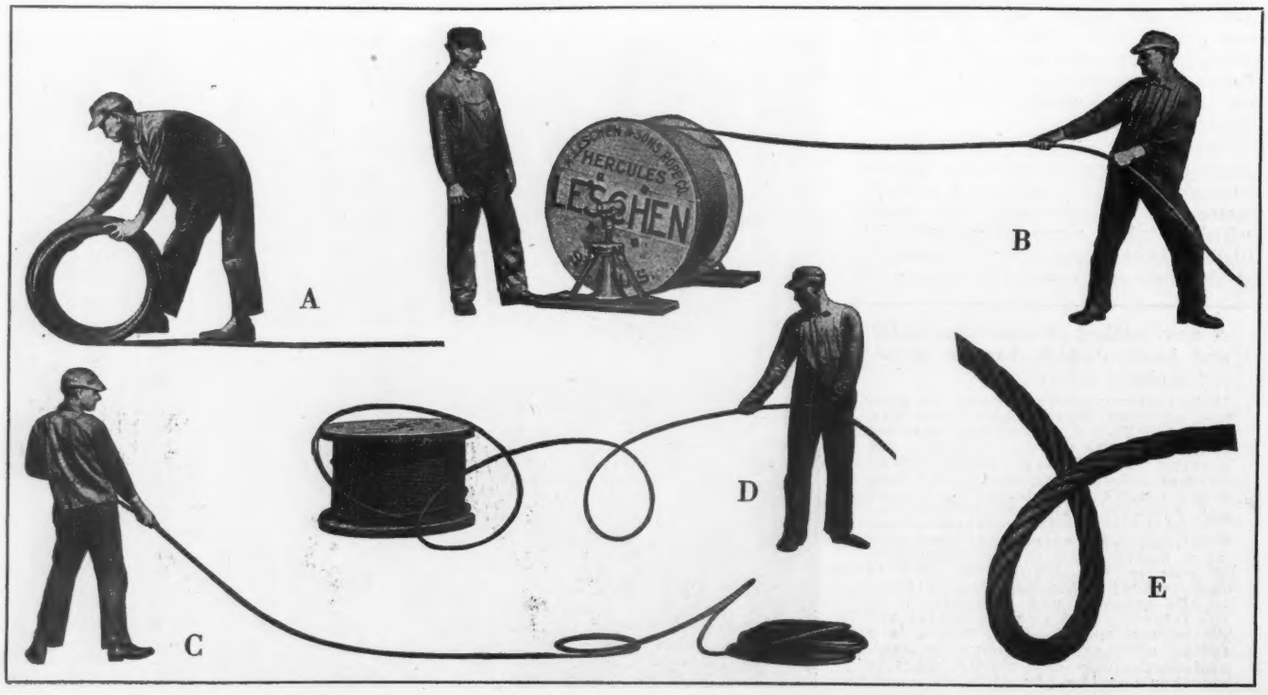
Avoiding Kinks in Unreeling and Uncoiling Wire Rope

INDUSTRIAL men frequently have occasion to remove wire rope from a reel or coil. When a wire rope receives a kink, as shown at (E) in the accompanying illustration, it is sure to have serious results upon the life and strength of the rope if actual breakage does not occur. The accompanying illustrations show the method of uncoiling and unreeling wire rope recommended by A. Leschen & Sons Rope Company, St. Louis, Mo.

When rope is received on a reel, the best way to remove it is to jack the reel up, as shown in (B), and uncoil it straight away. Care must be exercised to see that the reel does not turn too rapidly and loosen a coil or two which may slip over the end and result in a kink, if great care is not taken. When rope is received in a coil, it should be handled as shown in (A); that is, roll it on the ground like a wheel or hoop. It should always be remembered that wire rope must not be coiled or uncoiled like hemp rope. When coiling a wire rope, if it should for any reason become looped, as shown in (D), the loop should be drawn out at once for if a load is put on the rope in this condition damage is bound to occur. In case a wire rope is to be coiled after being used, reverse the above operation. Illustrations (C) and (D) show what is bound to occur when a wire rope is carelessly unwound by laying the coil or reel on the ground.

These five illustrations show how and how not to unreel or uncoil wire rope.

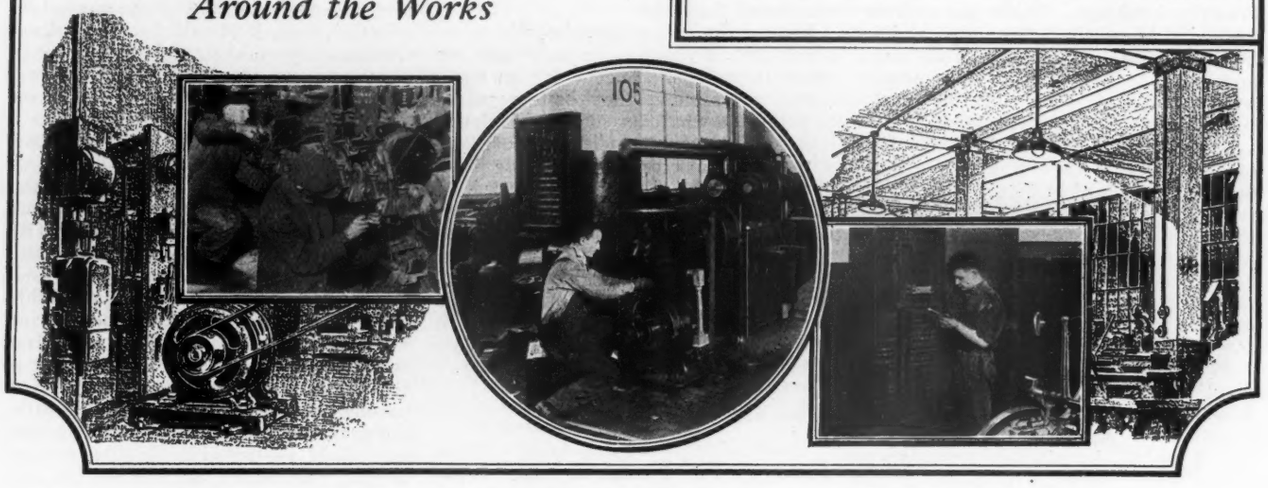
If a load or pull is applied to a wire rope with a kink in it, as shown in *E*, damage is almost sure to occur, with perhaps breakage as a result. Illustrations *A* and *B* show the right way, while *C* and *D* show methods which should never be used in the handling of a wire rope. In case it is desired to roll up the wire rope, operations *A* and *B* should be reversed.



Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



How Over-Lubrication and Dust Stopped a Motor

THE big surface grinder in the lower shop stopped suddenly one day. The group that gathered about the operator quickly diagnosed the trouble as "hot box" and in the motor "most probably, 'cause she's warm." The machinist who was sent to fix it up started on the hot-box theory and ran down one bearing after another until he had found all free except in the motor.

He couldn't turn the rotor and forthwith stripped the driving chain and sprocket off and removed the head of the motor on that side. It came off easily and, as the rotor did not pull out, he took off the other head. This, to his surprise, also came off easily. It was an induction motor and the rotor was stuck within the stator.

Following the conventional line of thought, a test was made to see if the bearings had worn so that the rotor had dragged on the laminations and thus gathered up particles that had finally enmeshed it. Such was not the case and the trouble was proven to be the accumulation of dirt and dust which, because of too frequent oiling, had formed a pasty substance that had finally gripped the rotor so that it had stopped the machine.

The cleaning out that followed removed the source of trouble. Since then, a slowing up of motors has been taken as an indication that a thorough cleaning is needed because the very small air gap is getting stopped up again.

DONALD A. HAMPTON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Eliminating Trouble by Replacing Crane Trolley Wires With Flexible Cable

MAINTENANCE expense on electric traveling cranes in this plant has been considerably reduced and reliability of operation greatly increased within the past year and a half by replacement of the bridge trolley wires with multi-conductor flexible cables as described below.

The traveling crane equipment includes four 5-ton cranes with a maximum travel of 180 ft. and bridge span of 46 ft. The bridge rails are 29 ft. above the floor. Power supply to the motors is three phase, 60 cycles, 550 volts. The trolley drive motor, bridge drive motor and the hoist motor are respectively of 3, 15 and 30 hp. capacities and are all slip-ring motors controlled by drum controllers and secondary resistors.

The cranes are used for the distribution about the mill rooms of rolls of goods in process and cans of daub for coating the goods. During normal operation of the plant the crane shown in the accompanying photograph is required to make approximately 650 lifts in a period of 20 hr. thus allowing on the average about 2 min. for lifting, transporting and lowering a load. The crane is thus in use practically all of the time.

Breakdown of a crane in any one of the mill rooms seriously interferes with production especially where loads must be transferred from floor to balcony machines or the opposite. The practicability of the racks shown in the illustration for temporary storage of goods in process also depends upon reliable crane service. For the above reasons efforts have been made to make crane breakdowns as infrequent as possible. The possibility of cans of daub mixed with naphtha being ignited by sparks falling from poor contacts also necessitated removal of this hazard.

The original V-shaped, sliding shoe current collectors for the hoist and trolley drive motors were cut into by the No. 4 hard-drawn copper trolley wires on the bridge, which necessitated

The use of flexible cables in place of crane trolley wires on this and two other cranes improved operation considerably.

The old installation gave continual trouble and caused sparking which was a hazard due to the naphtha in use. Part of the trouble was removed by replacing the 9-ft. rails with 36-ft. rails and welding and grinding the joints. At the same time the sliding contacts were replaced with trolley-wheel collectors.

the making of frequent adjustments, replacements and inspections.

After a trial installation of trolley wheel collectors on one of the cranes all of the sliding contacts were replaced with standard wheel collectors with graphite bushings. These gave somewhat better service than the sliding contacts but did not reduce maintenance appreciably. Sparking at the contacts was caused mainly by vibration of the trolley wires which were spaced 4½ in. apart in vertical planes. The vibration of the wires in turn was attributable mainly to an unfortunate original installation of rails cut to 9-ft. lengths thus giving twenty rail joints to the length of the mill room. These rails have recently been replaced with 36-ft. rails and the joints have been welded and ground so that vibration from this source has been minimized.

Previously, however, to the replacement of the rails, the idea of using a flexible cable in place of the crane trolley wires was considered. After an experimental installation, permanent cables were installed on three of the cranes. The conductor system of the cable consists of ten No. 10 B. & S. extra-flexible (65 strands No. 28 wire) r.c. wires and three No. 2 extra-flexible r.c. wires. The ten No. 10 wires include the primary circuits to the two motors on the trolley, the secondary circuit of the 3-hp. motor and the limit switch conductor; the three No. 2 wires are the secondaries of the 30-hp. hoist motor. The thirteen wires extend from a terminal box, mounted on the side of one of the main bridge members in a readily accessible place above the cab, through 2½-in. Greenfield connected to the 2½-in. rigid conduit which can be seen in the picture extending from the left end of the bridge along side of the carriage rail to a point near the center of the bridge. Here the rigid conduit connects to a 3-ft. piece of Greenfield which is strapped to a curved sheet-metal plate. From the junction of this section of Greenfield with the rigid conduit, through the loop, up to the junction box shown on the right side of the carriage, the conductors are carried in 2-in., internal diameter, 4-ply rubber hose, the last 6 ft. of which is pulled into another section of Greenfield. This part of the cable is supported by a rigid bracket bolted to the carriage and extending about 18 in. outside of the first section of the loop to allow for the passage of the trolley back and forth across the bridge without interference between the two sides of the loop.

The length of the loop is such that with the trolley at the extreme right of the bridge, there is sufficient clearance between the loop and the balcony railing without too much tension on the cable and consequent strain on its supports. With the trolley in the center of the bridge, there is a clearance of 5 ft. between the loop and the storage racks shown. Clearance between the ends of the journals on which the rolls are carried and the loop is sufficient so that in ordinary operation the journal cannot hook into the cable.

From the above, it is evident that the local conditions such as low amperage of the 550-volt motors which permitted the use of a comparatively light cable, the ratio of bridge length to height above the floor, and clearances, favored the installation of the cables and the resulting improvement in operation has warranted their use.

Two of the cables have been in operation over a year and a half and one since July, 1923. Except for an occasional adjustment, they have required no attention whatever to date. Holdups due to the troubles with the original wire and collector system have been eliminated; the fire hazard caused by sparks falling from poor contacts has been removed; and maintenance expense on the electrical equipment of the cranes has been reduced approximately 75 per cent. If the conductors break from repeated bending it will be comparatively easy to replace them.

G. R. WELLS.
Plant Electrical Engineer,
The Standard Textile Products Co.,
Buchanan, N. Y.

How to Tie Underwriters' Knot in Lamp Cord

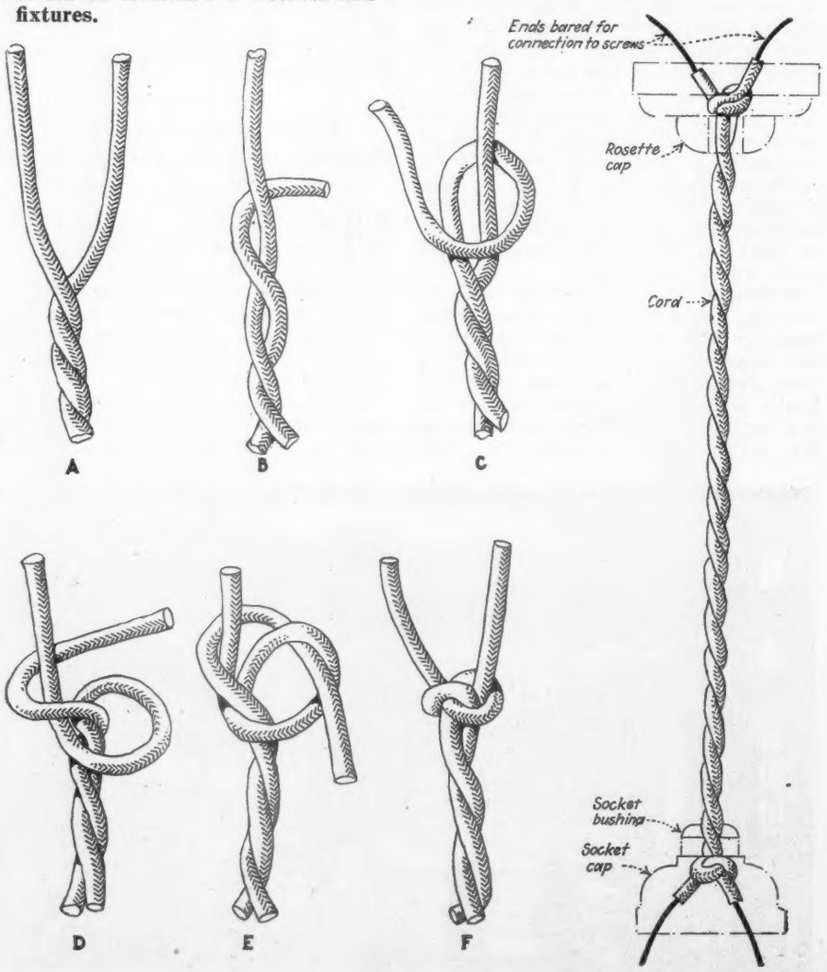
EVERY wireman knows that it is necessary to tie the ends of lamp cord after it has been inserted in socket caps and other fixtures, in order to avoid the possibility of the wires being jerked loose from the terminals by a strong pull on the cord. Also, if the ends are tied there is less likelihood of the cord untwisting. Oftentimes, however, the knot at the ends is improperly tied, so that it is much less effective than it should be. The illustration shows a sketch which I drew to show our men how the Underwriters' knot, as it is called, should be tied when making installations.

Starting with the ends of the two conductors slightly separated, as at (A), the one at the right is looped loosely around the other, passing back of and in front of it, as shown in (B) and (C). The second, or left-hand conductor is then bent to the left and looped, (D), around the first, or right-hand, conductor and the end passed through the loop formed by the first conductor, as in (E). When the knot is tightened by holding the two ends and pulling on the cord the knot will assume the shape shown in (F). The conductors can then be cut off to the desired length, the insulation skinned off and the wires fastened under the terminal screws as usual.

A knot made in this way will not slip or twist and, as shown at the right, is large enough so that it can not, under any ordinary circumstances, be pulled through the opening in the fixture.

San Juan, Porto Rico. F. KRUG.

Method of tying Underwriters' knot in lamp cord to prevent strain on terminals of sockets and fixtures.



Standard Power and Speed Ratings for Vertical Alternators

IN PLANNING for installations of vertical alternators of small and medium capacity it may be worth while to know what power and speed ratings may be obtained. The Electric Machinery Manufacturing Company, Minneapolis, Minn., have standardized in sizes

80% P.F.		SPEEDS AT 60 CYCLES																
Kv-A	Kw.	430	400	360	327	300	277	257	225	200	180	164	150	138	128	120	112	100
63	50				●	●	●	●	●	●	●		●	●				
75	60				●	●	●	●	●	●	●		●	●	●			
94	75	●	●	●	●	●	●	●	●	●	●		●	●	●	●		
125	100	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
156	125	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
188	150	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
220	175	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
250	200	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
312	250	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
375	300	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
438	350	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
500	400		●	●	●	●	●	●	●	●	●	●	●	●	●			
563	450		●	●	●	●	●	●	●	●	●	●	●	●	●			
625	500			●	●	●	●	●	●	●	●	●	●	●				
750	600			●	●	●	●	●	●	●	●	●	●					
875	700			●	●	●	●	●	●	●	●	●	●					
1000	800				●	●	●	●	●	●	●	●	●					
1250	1000					●	●	●	●	●	●	●	●					

Vertical alternators of the standard power and speed ratings indicated by the black spots, may be obtained from one manufacturer.

from 50 to 3,000 kva. and at speeds from 72 to 600 r.m. The accompanying graphic chart gives the 60-cycle ratings of the small and medium sizes as standardized by this manufacturer. Each black spot on the chart represents a standard speed rating.

Unusual Combination of Grounds Cause of Trouble

THREE years ago a large industrial plant made a wage reduction in all mechanical departments. On the day this reduction went into effect all the plant executives were down early, to be on hand in case any trouble should arise over it. However, everything went along as usual, until about 10 o'clock, when the electrical department was suddenly flooded with trouble calls from all parts of the plant.

Right at this stage it appeared to be a well-planned and timed retaliation. On sifting out the various troubles it was found that a 1,000-kw. motor-generator set had grounded through the motor field; one of the field leads to an 800-hp. synchronous motor had burned off; and grounds had developed on half a dozen elevator and conveyor motor controls.

Naturally, it did appear mysterious at first that all these troubles should develop at once, but apparently the grounds on the elevator and general power feeders and motor-generator set motor field had been accumulating for some time. Then, when the ground developed on the 800-hp. synchronous motor field, a short circuit resulted. Owing to the arrangement of the circuit breakers on the switchboard, the only protection was through the main generator breakers, which were set at 8,000 amp. The net result was the burning of leads and damage to equipment that took the balance of the day to clear up.

After this occurrence ground lamps were installed in the substation at a negligible cost, and grounds have since been cleared up as soon as they develop. In this case these lamps have proved more satisfactory than a regular ground detector, for it is usually possible to locate the ground from the action of the lamps. For instance, in the case of an intermittent ground, such as on elevator controls, by observing the feeder ammeters in connection with the lamps the ground can be approximately located. Again, in the case of a more permanent ground, by furnishing the electrician with a report of the time on and off he has a good clue to work on without going through a tedious cut-and-try process. The advantage of the lamps over an indicator or voltmeter is that they are always under direct observation without being actually watched.

Another point to be brought out here is the apparent fact that single-pole trip protection is not sufficient on two-wire circuits fed from three-wire busbars, as in this case.

Akron, Ohio. E. J. DEL VECCHIO.

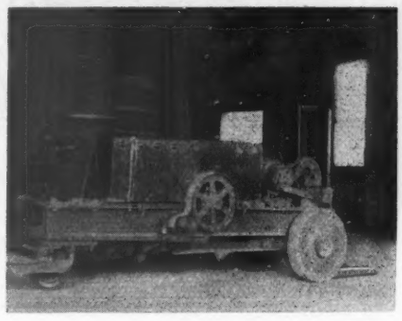
Construction of Annealing Kiln Charging Truck

TO FACILITATE the charging and emptying of a number of annealing kilns in a malleable-iron foundry, a handy and efficient truck was constructed, mostly out of material on hand from discarded trucks, together with some parts made by the machine department and a few which were purchased, mainly pinions. The truck is 12 ft. long over-all, 30 in. wide, 3 ft. high to the top of the battery box and 4 ft. 6 in. to the top of the lifting fork. It weighs 1¼ tons and is operated by two 1½-hp. battery motors, four-pole, series wound, 40-amp., 24-volts, 1,000 r. p. m. at full load. One motor is situated forward and drives 4-in. pinions meshed internally in both of the heavy front wheels. The front wheels are 20 in. in diameter and 4 in. wide, with iron treads shrunk on. The wheels are solid cast and turn on ball bearings. An 8-in. brake wheel is also keyed on the drive motor shaft. The brake band is a full circle and is operated through a toggle motion by the operator releasing the pedal.

The pots containing the castings to be annealed weigh from ½ to 3 tons and are lifted 4 in. by the fork, which is operated by a motor slung under the rear of the tractor. This motor, through a worm gear, tips a beam up and down, the movement of which is checked by a cam throwing out the electric switch near the operator. The lifting form is solidly cast on one end of the beam.

A pedal operates the main switch and releases the brake of the traveling motor. The tractor is steered by a 15-in. handwheel which turns the single rear wheel through a pinion. This wheel is solid, 12 in. in diam., 6 in. thick, and runs on ball bearings. A stop pin on each side prevents the wheel from turning too far in either direction.

All of the wiring is No. 6 flexible, stranded, rubber covered in 1¼-in. iron conduit. The battery power is supplied by twenty-five A-6 Edison cells, charging rate 45 amp. These are contained in trays of five each; sheet fiber is used between the battery and the sheet-iron case enclosing them to prevent grounding. The cover is also lined with sheet fiber to prevent short circuits against the caps of the cells. Large holes are provided all around the



This charging truck handles loads which formerly required five men to move.

In addition the truck can do this work faster and go into hot places where men could not work. If not interfered with the truck can in 40 min. load or empty a kiln containing forty-two pots weighing 20 tons. It was made up largely of spare parts of discarded trucks.

sides of the enclosing case to lead off the potash gas. A 100-amp. charging plug at the rear end of the battery box connects with the charging line.

The truck was tried out with the Edison A-4 cells, but a charge would not hold up for half a day under the heavy work done. The A-6 cells were then installed. The battery solution has to be renewed every four months. The tops of the cells are cleaned off frequently with compressed air, and the exposed wiring and leads varnished.

The kiln truck is worked so hard that the cells need watering every day. A charge of from 60 to 100 amp. is given for short periods, and a 50-amp. charge for eight hours every night. It is operated by one man, and when the road is clear he can load or empty a kiln and handle forty-two pots of castings, weighing 20 tons, in 40 min. The traveling motor is operated by a drum controller having three speeds forward and reverse.

A 100-amp. knife blade charging switch with enclosed fuses is installed on one side of the annealing room wall where the truck is stored when not in use. Alongside of this is an attachment plug receptacle which is handy for an extension lamp or drill when repairs are needed. The switch fuse and other live parts are contained in an asbestos-lined cabinet, with a pilot lamp on top wired to indicate whether or not the charge is on. A No. 00 rubber-covered two-wire line supplies the 115 volts direct current. The charging switch is closed for the night at 5 p. m. and is opened by the watchman at 1 a. m.

New Britain, Conn. H. S. RICH.

Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Application of Ball Bearings to General-Purpose Motors

THE many advantages gained by the use of ball bearings in all kinds of machinery from mill shafting to gyroscopes, from automobiles even to wheel-barrows, has so far demonstrated their usefulness.

Perhaps in no other field are the advantages in the use of ball bearings more apparent, and the benefits more certain than in that of electric motors. No special arrangements are necessary for belting in different directions. Up, or down, or on the side, makes no difference in their efficiency.

Motor efficiency is, of course, largely dependent on the maintenance of a uniform air-gap and as wear in properly made ball bearings is very low, it is evident that by their use a uniform relation between rotor and stator windings can be obtained.

In many instances the user of sleeve bearings holds to one make of motor, simply to keep down his stock of sleeve bearing replacements. The carrying of different bushings for two or three makes of motors represents considerable stock for which space must be provided. It also means quite an investment. All this is necessary with sleeve bearings, as each designer of motor bearings works out his own pet schemes in his sleeve-bearing design, with the result that every type and make of motor requires its own particular bearing. The use of ball bearings entirely overcomes this condition as the different makes of ball bearings are standardized to internationally-accepted dimensions. The modern, deep-grooved, chrome-steel ball bearing is now made to high-grade standards and in identical sizes by several manufacturers so that the sources of supply and reliability of service are well assured.

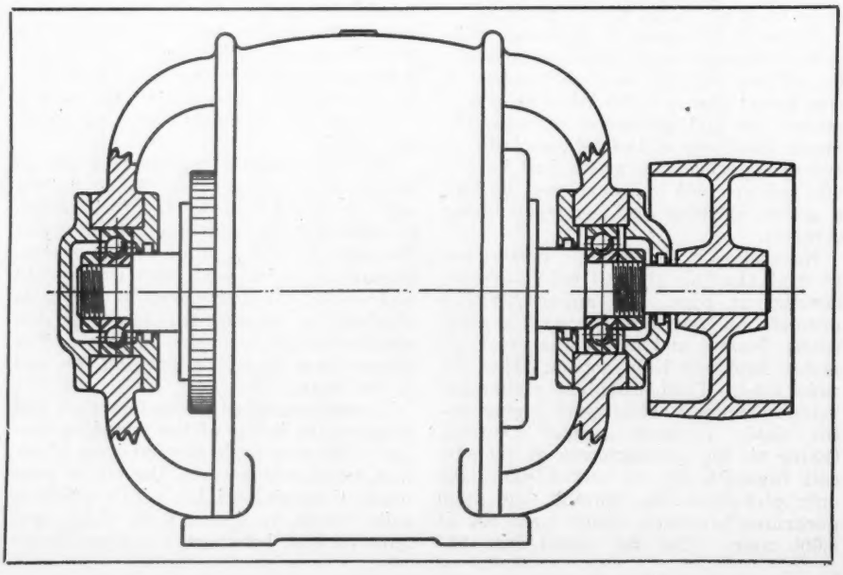
Motors, ball-bearing equipped, will give constant service provided the ball bearings are properly selected and properly housed. If, however, due to errors of design, ball bearings require replacements, provided stock is not available, the nearest bearing service station is in a position to give immediate service. These stations are established in all the larger cities and carry stocks of all the popular sizes.

There are requirements today where no sleeve bearing will serve. For such places all makers now supply ball-bearing motors, even when the same maker does not supply or recommend ball bearings for his general-purpose line. Such a requirement is found in the driving motors for tilting tables in rolling mills. There the motor tips up and down as the steel is fed, first through the upper rolls and then through the lower.

The lubrication of ball bearings for motor service is best accomplished by allowing ample space around the bearing and packing with grease. This insures a clean motor with no oil soaked winding.

The proper application of ball bearings requires somewhat more careful machine work than is generally given to sleeve-bearing applications. It is also necessary that grit of any kind be excluded. This is easily accomplished with correct design. The accompanying drawing shows standard, ball-bearing practice. Note that the bearings are driven on the shaft against the shoulders. These shaft shoulders must be high enough to give a bearing against the flat face of the inside ring. On the larger sizes there should be also provided lock nuts as shown. On the smaller motors, however, pressed-on sleeves are sufficient. The end bell housings show one bearing held against side motion. This is accomplished by simply facing a small amount from the inside face of the end covers.

To make the application of ball bearings to electric motors the simplest possible stock proposition, the leading manufacturers of ball bearings have

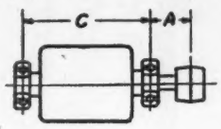


This detail drawing shows an accepted practice in the mounting of ball bearings in motors.

How to Use This Table for Finding Ball-Bearing Sizes for Use on Horizontal Motors

In the diagram at the top of the table C represents the distance between the centers of the motor bearings and A is the distance between the center of the pulley end bearing and the center of the face of the pulley. By means of these dimensions the pulley overhang ratio $(C+A) \div C$, is determined which together with the motor horsepower and speed and the pulley, belt and shaft dimensions are the factors governing the selection of the bearing. Bearing sizes are listed for a medium, heavy and wide series for the pulley end bearing, with alternatives for the heavy series and wide type, and also the sizes for the other bearing of the motor.

STANDARD BALL BEARING SIZES FOR GENERAL PURPOSE ELECTRIC MOTORS



ELECTRIC POWER CLUB STANDARDS			HORSEPOWER			RECOMMENDED ANNULAR BALL BEARINGS S.A.E. STANDARDS					
						PULLEY END					OTHER END
						MEDIUM SERIES			ALTERNATIVES* HEAVY SERIES	ALTERNATIVES* WIDE TYPE	
PULLEY DIA.	BELT WIDTH	SHAFT EXT. DIAM	1750/1800	1150/1200	850/900	PULLEY OVERHANG RATIO $\frac{C+A}{C}$			RATIO $\frac{C+A}{C}$		RATIO $\frac{C+A}{C}$
INS.	INS	INS	R.P.M.	R.P.M.	R.P.M.	MIN. 1.26	MAX. 1.40	AVG. 1.33	NOT TO EXCEED 1.40		NOT TO EXCEED 1.40
3	2	3/4	1	3/4		305	305	305			303
4	3	7/8	1½	1		306	306	306			304
						305	305	305			
4	3	1	2	1½		306	306	306			304
			3								
				2		306	306	306			304
5	4	1 1/8	5	3		307	307	307		306	305
					2						
5	4	1 1/4	7½			308	308	308			
				5		307	308	307		307	305
					3	307	307	307			
6	5	1 3/8	10			309	310	309			
				7½		308	309	308		308	306
					5	308	308	308			
7	6	1 5/8	15			310	311	310			
				10		309	310	309		309	307
					7½	309	309	309			
8	6	1 3/4	20			312	313	312		311	
				15		311	312	311	410	310	308
					10	310	311	310		310	
9	7	1 7/8	25			313	314	314	411	312	
			30			314	315	314	412	312	309
				20		312	313	313	411	311	
					15	312	312	312	411	311	
			40			315	316	315	413	313	310
				25		313	314	314			
10	7	2 1/8		30		314	315	314	412	312	310
					20	312	313	313			
					25	313	314	314			
11	10	2 3/8		40		315	316	316	413	314	311
					30	315	316	315		313	
12	11	2 5/8		50		317	318	317	415	315	312
				60		317	318	318	415	315	313
					40	316	317	317	414		
13	12	2 7/8		75		318	319	319	416	317	314
					50	317	318	318		316	
					60	318	319	319	416	317	314
15	14	3 3/8		100		319	320	320	418	318	316
					75						

* SHAFT STRESSES SHOULD BE CONSIDERED WHEN ALTERNATIVES IN HEAVY SERIES OR WIDE TYPE ARE USED

The engineers of the several American manufacturers of ball bearings listed below have recommended as engineering standards of the industry the accompanying ball-bearing sizes as applying to horizontal, general-purpose electric motors having present Electric Power Club pulley diameters, belt widths, shaft-extension diameters and having pulley overhang ratios lying between the maximum and minimum values as shown. These standards do not apply to motors for special purposes nor to those having dimensions and overhang characteristics beyond the range given in the table. The engineering departments of these companies will gladly furnish additional data and recommendations for the application of ball bearings to special conditions not covered herein:

The Fafnir Bearing Co.; Marlin-Rockwell Corp., successor to Gurney Ball Bearing Co.; The New Departure Manufacturing Co.; SKF Industries, Inc.; Strom Ball Bearing Manufacturing Co.; Standard Steel and Bearings, Inc.

given most careful consideration to the requirements of this service. In the preparation, nearly every American make of motor was studied. The accumulated data shown in the accompanying table was turned over to a Committee of Ball Bearing Engineers who had made a special study of electric motor requirements. The recommendations in the Committee report were drawn up and subscribed to by the co-operating companies.

This recommendation is the collective experience of the Committee, and is a safe guide for bearing selection when its conditions are complied with.

It will be noted that these specifications, covering a range of motors from ¾ hp. to 100 hp., require a total of only sixteen sizes of ball bearings for all sizes of motors, with an alternative of nine additional sizes for extra-heavy duty on the larger motors. These bearings are standard sizes, not only in this country, but throughout the world. The unanimous endorsement of bearing sizes by practically all of the leading manufacturers of bearings not only relieves the motor manufacturers from the danger of improper selection of bearing sizes, but insures to the user the utmost in reliable and efficient performance and easy replacement in case of accident. In every way these specifications should mark a distinct advance in standardizing motor design.

[These statements concerning the use of ball bearings in motors were taken from recent engineering literature issued by The Fafnir Bearing Co., New Britain, Conn., and The New Departure Mfg. Co., Bristol, Conn.]

Tests Prove Which Side of Leather Belt to Put Next to Pulley

BECAUSE some users of leather belting are in disagreement as to whether the grain (hair) or the flesh side of the leather belt works best next to the pulley the Leather Belting Exchange, an association of manufacturers of leather belt, ran a series of tests in its laboratory in connection with Cornell University. For these tests, five first-quality, 4-in. leather belts made by different manufacturers were used over two 24-in. pulleys operating at a shaft speed of 500 r.p.m., or 3,100-3,200 ft. per min. belt speed, which was selected as being of average shop speed. Tests were run at tensions of 36 and 54 lb. per in. of width. In all of the testing work it was found necessary to run-in the test belts thoroughly before any final conclusions were drawn.

The fact that the flesh side has nearly its maximum capacity from the first while the grain side requires more running-in, may lead an inexperienced user to conclude that the flesh side is the best for transmission. In one case, the first test on the grain side was below the first on the flesh side, and yet the grain side after 6½ hr. of running-in surpassed even the final tests on the flesh side. With further running-in this improvement continues until the grain side transmits three times as much power as the flesh side.

None of the five belts transmitted its full capacity when first put on. Usually the better belts improve the most rapidly, but this is not always so. The rate of improvement does not seem to be constant, but varies throughout each period of running-in. In some cases the flesh side tends to decrease in capacity with continued running-in. The conclusions reached were:

(1) Under the average shop tensions, the flesh side averages from 58 to 68 per cent of the capacity possessed by the grain side.

(2) In general, the grain side will transmit from one to three times as much power as the flesh side, depending on the belt, the tension, and the conditions of service.

(3) With some belts the flesh side has a greater capacity than the grain side when first put on the pulleys, but in no case was a higher capacity obtained for the flesh side after the belts were thoroughly run-in. This is because the flesh side usually had nearly its maximum capacity at the start without running-in, while the grain side required a period of running-in to reach this point.

(4) Where there is an increase in the capacity of the flesh side due to running-in, it is usually less than the corresponding increase due to running-in the grain side.

(5) The capacity of the flesh side may decrease slightly with continued running-in.

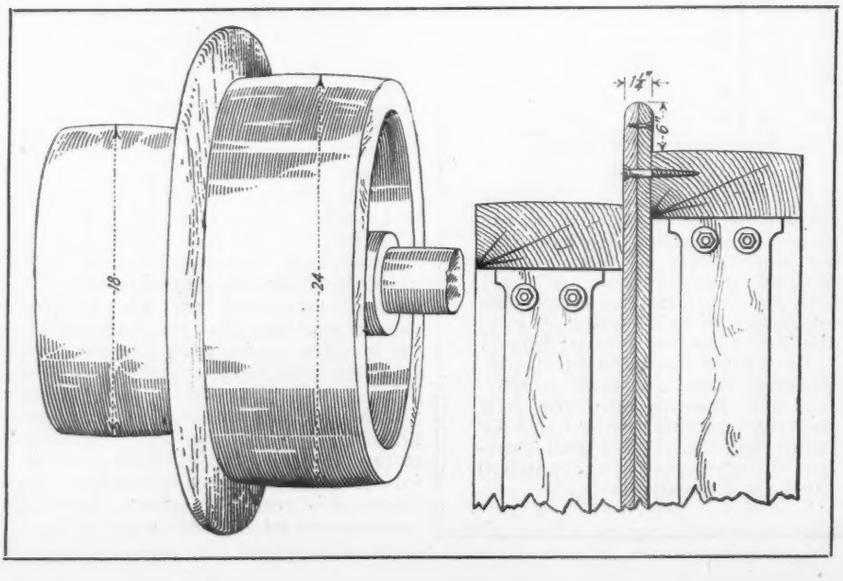
(6) The time of running-in on the grain side, required to bring these belts up to rated capacity (20-25 hp.), varied from 5 hr. with the better belts, to 40 hr. with the poorest. To bring them to approximately maximum capacity required from 20 to 63 hr.

Novel Use of Wall Brackets for Mounting Motors

WHEN mounting motors on a wall, it is not always necessary to forge out triangular arms or braces to support the mounting platform. In the new Chicago plant of the Brunswick-Kroeschell Company, ordinary cast-iron wall brackets which are used for supporting lineshaft hangers or pillow blocks, were attached to the wall and used as a support for the motor platform, as shown in the accompanying illustration. Each bracket has a T-groove to which the platform may be bolted without the necessity of boring any holes in the iron frame. Many plants have surplus equipment of this sort on hand which could be used in this way. It would probably be as economical and as easy to purchase new brackets as it would to make a special iron framework.

Here the motor is mounted on an easily-constructed platform.

Instead of building a special iron framework upon which to mount the motor platform, these cast-iron wall brackets were attached to the wall. T-grooves made it easy to bolt the platform on to the bracket and also permit of adjusting them as desired. The motor is controlled by a push button as shown. The four chains are used for opening sash in the monitor roof.



With this special flange belts are run in opposite directions, although the pulleys are placed close together.

Operating Belts Where Pulleys Are Close Together

EXPERIENCED millwrights know of the risk involved in running two belts on one pulley. It does not make any difference whether the belts take off in the same or opposite directions. The least side slap, which causes the belts to touch, or the breaking of a belt results in a disaster of greater or less degree. The same is true of two pulleys of different diameters that are placed side by side, because belts have a propensity for crowding toward each other and the inevitable accident follows.

It is for this reason that the experienced man always leaves plenty of room between pulleys. Good practice requires a space wider than the width of either belt and it is preferable to make that space double if there is any way of arranging drives to this end. A common practice, though one not recommended, is to fasten a stick from overhead so that it keeps the belts separated; this, however, is weak because it occupies so little space and a belt can sway or its free end slap around the stick until it comes into contact with the other belt on the moving pulley.

One plant in the screw products industry found that its production arrangement of machines called for a score or more of these danger points. A 24-in. pulley had to be set on the line-shaft tight up against an 18-in. pulley with no good way to avoid it if floor space were to be conserved. The plant was built in 1917 and these pulleys have been run safely and satisfactorily ever since by the scheme shown below. The belts from these pulleys run in opposite directions.

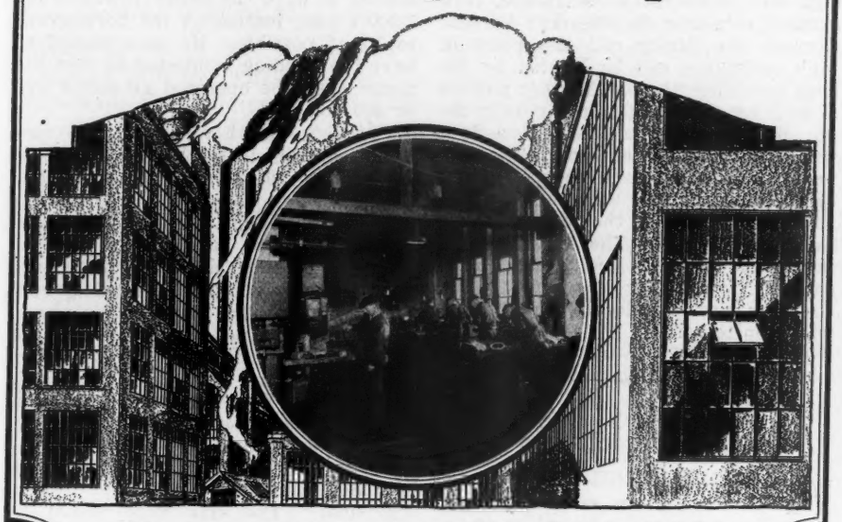
A wooden flange was made up for each pair of pulleys. No attempt was made to skimp on the quality of the lumber or to make a cheap job, for it was realized that to be of any good at all, the flange must be made right. At that, the cost was low because the full number were made at once which greatly lessened the set-up time.

Seasoned maple was used for the flanges which were made in the form of discs, laminated to minimize warping, and with the plies laid at right angles. Commercial "one inch" stock was used which usually planes to 25/32 in. It was planed still thinner in order that the finished flange would not occupy more than 1¼ in. longitudinally on the shaft.

Referring to the drawing, it will be seen that the separate plies are screwed and glued together and that the whole is screwed to the rim of the larger pulley and split, becoming to all intents a part of the pulley. These were placed on a mandrel and lathe turned to make them concentric and true and the corners well rounded to prevent belt chafing.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Portable Post Bench with Vise for Construction or Repairs

FORMERLY in a structural iron shop the work required the use of pipe vises at various positions throughout the shop. These were fastened with lag screws to the wooden posts which supported the roof. The posts were drilled and the lag screws holding the vise base were screwed directly into the posts.

Obviously abuse and contact with plates and girders which were being swung about was detrimental to the life of the posts and in a few years they were replaced by steel columns. The foreman then decided it would be unwise to drill each of the columns for bolting the vises into position, while at the same time facilities for grouping vises adjacent to the work were desired.

To accomplish this a vise-handling method was adopted, which is shown in the illustration. However, this has features which make it a most desirable idea for any shop requiring either portable pipe or bench vises or for repairmen. Several oak blocks 6 in. x 6 in. x 3 ft. were made with undercut or mortised sections about an inch deep at the center to fit the columns as shown. Each of these blocks was bored near the ends for long through-bolts. At the ends of these blocks, both top and sides, holes were drilled for attaching pipe or bench vises. These blocks are readily removed and may be stored in the corner of the shop when not in use. Whenever vises are needed, it is only a matter of putting up two blocks and inserting the through-bolts. One or more vises can then be placed to meet any requirements. Apart from the portable and removable feature of these improvised benches, they are adjustable for height and have a space in which tools may be placed, which is a distinct advantage.

Washington, D. C. G. A. LUERS.

Although this post bench was made for the Production Department, repairmen will find it useful.

With several pipe and bench vises, like these mounted on 6-in. x 6-in. timbers it is easy to erect a temporary stand almost anywhere in the shop. Where repairmen have a truck to carry their tools around a pair of these blocks may be included.

How to Locate Common Troubles in Armatures

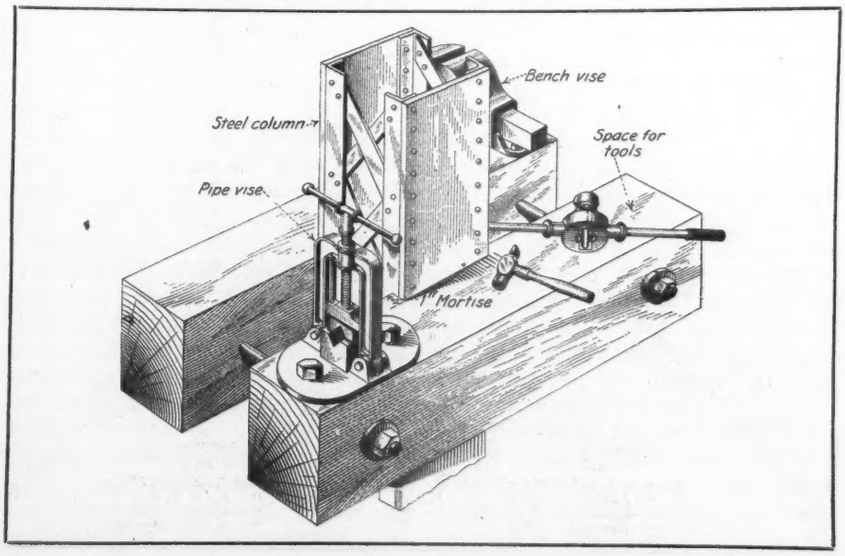
DEFECTS in the armatures of direct-current motors and generators show up in various ways but can ordinarily be located without a great deal of difficulty. If a few of the symptoms and causes of the more common defects are well known, the diagnosis and location of these troubles is still further simplified. For this reason the following suggestions may be of interest to readers of INDUSTRIAL ENGINEER.

A short circuit in an armature coil is a very frequently encountered trouble which is indicated by flashing at the commutator and heating of the armature and will result in burning out of the coil unless it is cleared up. This defect is usually caused by metallic particles of some kind bridging across the insulation between the commutator bars, by the risers being knocked together, on lap-wound armatures, or by one or more turns of the coil coming into direct contact and causing a short circuit.

The faulty coil can usually be located by its excessive temperature compared to that of the rest of the coils, by the baked appearance of the insulation of the faulty coil or by measuring the resistance. If the trouble is in a generator the brushes can be raised from the commutator and with the fields properly excited the armature may be rotated for a few moments at a time. The short-circuited coil, which is of low resistance, will generate a heavy current causing it to heat.

A ground at one point in an armature winding will not always cause serious trouble, although it is a source of danger to the operator, but if the insulation should break down at a second point in the winding a short circuit is produced and a burn-out will result. A good method of locating a grounded armature coil is to pass a direct current of a few amperes through the armature by its own brushes. Touch one terminal of a voltmeter, or a galvanometer which is not too sensitive, to the shaft of the armature and with the other terminal lead make contact with the commutator bars in succession until contact with a certain one of the bars will show no deflection of the instrument. The coil connected to this bar or the bar itself will be found to be grounded. If a galvanometer is used, care should be taken to keep it far enough away from the armature so that it will not be affected by the armature magnetism.

A ground or partial short circuit be-



tween coils is manifested by heating and sparking. In the case of a bipolar generator, excite the field coils and turn the armature over by hand. It will be found that the armature will turn quite hard until it reaches a certain position, where one-half of the armature will oppose the other half. At this position mark the armature at the center of the pole pieces and the trouble will very nearly always be found in coils under the marks. If the generator is multipolar, all but one north and one south pole directly opposite should be cut out of circuit and all of the brushes lifted except those for the two active poles. The field may then be excited and the test made as above. The same test holds good for a motor; excite the field and limit the current in the armature to a value at which the armature will just rotate. Then by turning the armature by hand against rotation a position will be found at which the armature will have no torque. It will be found that the coils directly under the middle of the pole faces when the armature has no torque are the faulty coils.

An open circuit or high resistance in the armature circuit causes heavy flashing at the brushes and produces flat spots on the commutator. There will be sparking each time the segment to which the coil is connected passes under a brush. This trouble is distinguished from that caused by a short-circuited coil by the fact that the armature as a whole is not heated. The open circuit or high resistance is usually found on the commutator or riser, whichever it may be. As a rough test, in case of high resistance in the armature, if a current of a few amperes can be sent through the faulty coil the point of high resistance can be located by the heat developed there. Another method of locating these faults involves the use of an ammeter connected to a low-voltage source of current. The terminals should be small enough to rest on a single commutator segment and should be applied to the commutator at two opposite points. The ammeter reading should be noted and the armature rotated slowly. At the point where the open circuit is located the reading will drop to zero.

Muncie, Ind. GEORGE CROPPER.

Motor Rewound for Two Voltages and Different Speed

AN INTERESTING problem came up recently in connection with rewinding a motor for operation on two different voltages, with a change in speed. This was a Westinghouse motor, type CCL, three phase, 60 cycle, 10 hp., 220 volts, 25.8 amp. per terminal, 850 r.p.m. The old winding consisted of forty-eight coils of sixteen turns each of three No. 14 d.c.c. wire, in ninety-six slots, coil pitch 1-and-12, connected two-parallel star. The owner wished to have the motor rewound for 1,200 r.p.m., increasing the horsepower to 15, if possible. He also wished to have the winding connected so that the motor could be operated on either 220 or 440 volts.

Checking the horsepower, the new rating of this 900-r.p.m. motor would be $(1200 \times 10) \div 900$ equals 13⅓ hp., but according to data on hand, this frame is good for 15 hp. at 1,200 r.p.m. At 440 volts the amperes per terminal would be 20 amp.; at 220 volts, 40 amp.

The old or 900 r.p.m. winding consisted of $48 \div 3 = 16$ coils per phase, with 16 turns per coil or a total of $16 \times 16 = 256$ turns per phase. Then for 1,200 r.p.m. the turns per phase equal $(256 \times 900) \div 1{,}200$, or 192 turns. As a two-layer winding was required, there would be ninety-six coils, with $96 \div 3 = 32$ coils per phase. The turns per coil would be $192 \div 32 = 6$ turns per coil. The size wire would be $(256 \times 12{,}321) \div 192 = 16{,}428$ circ. mil. One No. 14 wire has an area of 4,107 circ. mil, and three an area of 12,321 circ. mil. Then $16{,}428 \div 4 = 4{,}107$; therefore, four No. 14 d.c.c. wires would do. The new two-layer coil would have six turns of four No. 14 d.c.c. wires per coil, or $2 \times 6 \times 4 = 48$ wires per slot; the old winding had $16 \times 3 = 48$ wires per slot, both windings having the same space factor.

The eight-pole pitch was 1-and-12; full pitch would be $96 \div 8 = 12$ or 1-and-13. Then 1-and-12 is $11 \div 12 = .92$ or .92 per cent pitch. The six-pole pitch would be $(96 \div 6) \times .92 = 14.72$ or 1-and-14 would do.

The chord factor of the 1-and-12, eight-pole pitch was $96 \div 8 = 12$, and 180 deg. $\div$ 12 = 15 deg. Then the sin of $(11 \times 15) \div 2$ or 82 deg. 30 min. equals .99144 and the chord factor of the 1-and-14, six-pole pitch would be $96 \div 6 = 16$, and $180 \div 16 = 11.25$ deg. The sin of $(11.25 \times 13) \div 2$ or 73 deg. 7½ min. equals .9569. The 1-and-14 pitch would be satisfactory, as increasing the pitch would also increase the coil projection beyond the iron and require more copper.

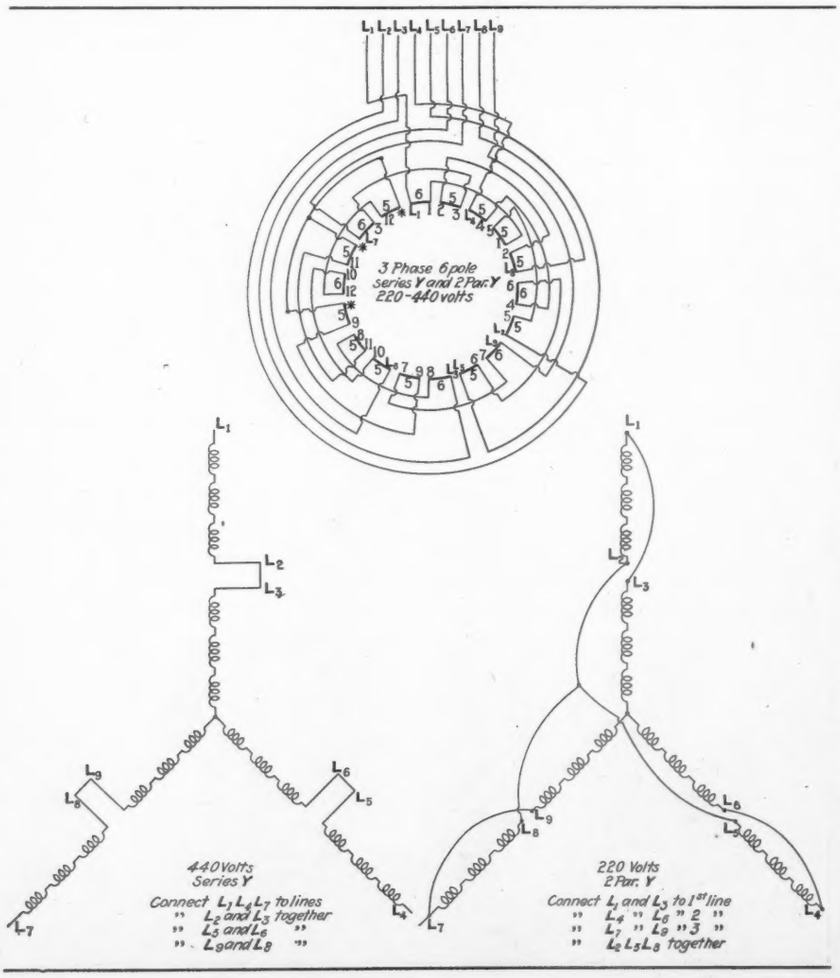
For six-poles, three phase, there would be $3 \times 6 = 18$ pole-phase groups, and with ninety-six coils there would be twelve groups of five coils in series and six groups of six coils in series, arranged as follows: 655, 556, 565, 655, 556, 565.

The motor was to be connected to operate on 220 or 440 volts and this was accomplished by using nine leads, making possible a series-star and a two-parallel star connection. The diagram shows this arrangement, and the method of making the change outside the motor.

The 1,200-r.p.m. data was, then, 15 hp., 220-440 volts, 40-20 amp. per terminal, three phase, 60 cycles. There were ninety-six coils, each coil consisting of six turns of four No. 14 d.c.c. wires in parallel, pitch 1-and-14, connected series-star for 440 volts, and two-parallel star for 220 volts.

Pittsburgh, Pa. A. C. ROE.

Method of connecting three-phase, six-pole motor for operation on 220 or 440 volts.


3 Phase 6 pole
series Y and 2 Par. Y
220-440 volts
440 Volts
Series Y
Connect L1 L4 L7 to lines
" L2 and L3 together
" L5 and L6 "
" L8 and L9 "
220 Volts
2 Par. Y
Connect L1 and L3 to 1st line
" L4 " L6 " 2 "
" L7 " L9 " 3 "
" L2 L5 L8 together

Laying Out Wave Windings

(*Continued from page 489*)

placed on the A_1 and C_1 leads so as to point into the winding, then the arrow on B_1 should point out of the winding. In the schematic sketch shown at the lower right-hand corner of Fig. 12, the A_1 and the C_1 leads are given a polarity such that the arrows point into the winding and the B_1 lead has a polarity such that the arrow points out of the winding. Then for the series-delta connection to be correct, in tracing around the delta, you should be able to follow through one phase against the arrow and the remaining two phases with the arrows; or if you started the opposite way, you would have two consecutive phases against the arrows and through the third phase with the arrow.

The next point in our consideration of wave windings is to determine how many circuits it is possible to secure. We will first consider the one-coil-per-cell, two-layer winding. This type of winding can only be connected in series or two-parallel. The way the two-parallel connection is obtained is shown in Fig. 16. This figure shows a four-pole, two-phase, left-hand winding, which is similar to the winding shown in Figs. 7 and 8. In any wave winding of this type, each phase is divided into two equal sections having two leads per section, or four leads per phase; that is, there will be two ingoing and two outgoing leads per phase. In Figs. 8 and 16 the two ingoing leads are B_1 and R_4 for the B phase and the two outgoing leads for the B phase are B_2 and R_3. If we remove the reversing jumpers and connect R_3 to B_2 and R_4 to B_1, and attach a line lead to the junction of each of these pairs of leads, we will have divided the phase in half, cutting down the turns 50 per cent and increasing the current-carrying capacity 100 per cent. In the A phase, the A_1 line lead is connected to the A_1 and R_2 leads and the A_2 line lead is connected to the A_2 and R_1 leads; that is, the starting leads of the two sections of the same phase are connected to one line and the finishing leads to the second line.

Fig. 17 shows how the three-phase, series-star connected winding shown in Fig. 11 was changed to make a two-parallel star-connected winding. First, open the reversing jumpers and connect the end of the first section of one phase to the star ring, and the other jumper lead, which is the start of the second section of the same phase, should be connected to the line lead that connects to the start of the first section of this phase. For the A phase, the first reversing jumper lead, R_1, will be connected to the star ring as shown in Fig. 17. The second reversing jumper lead, R_2, will be connected to the line lead that connects to the start of the first section; that is, it will connect to A_1 as is shown in Fig. 17. This procedure should be repeated for each phase. Then each line will have connected to it the starting lead of both sections in that phase and the finishing leads of all sections will be connected to the star ring. This layout is shown in the schematic sketch in the lower right-hand corner of Fig. 17.

The method of making a change from a series-delta to a parallel-delta connection is shown in Figs. 12 and 18. In Fig. 12, as was explained previously, is shown a series-delta connected winding. Fig. 18 shows the same winding connected parallel delta. The method of making a change from series-delta to parallel delta is to locate the line and reversing leads of each phase; then open the reversing jumper and connect the starting lead of the second section to the starting lead of this phase. Likewise, connect the finishing lead of the first section to the finishing lead of this phase. For the A phase, this would mean that R_2 would be connected to A_1, and that R_1 would be connected to A_2. Repeat this for each phase. Then the parallel sections, which we now have should be connected in delta as was explained previously. Each line lead should then have two top and two bottom leads connected to it. This is clearly shown in the schematic sketch in the lower right-hand corner of Fig. 18.

When a winding consists of two or more coils per cell it is possible to get still further parallel reduction. For example, take the winding shown in Figs. 13, 14 and 15. In this winding which has two coils per cell, it is possible to parallel the coils per cell, thus making it equivalent to a one-coil-per-cell winding of twice the cross section. Then the sections of the winding could be paralleled as shown in the previous paragraph. Hence, the conclusion may be drawn that it is possible when a winding has two coils per cell, to get the equivalent of a four-parallel connection regardless of the number of poles in the winding.

To parallel the two coils in any one cell, it would not be necessary to remove all the connecting clips and join each coil to its mate. The same effect could be obtained by removing the clips between the beginning and end of each section or at four places in a two-phase winding and at six places in a three-phase winding. The end and start of each slot series could then be reclipped and thus parallel the coils per cell. For example, in Fig. 13, we could remove the clip that connects lead O to top lead M, connect M to N to form the phase lead, remove the clip from P and L, then connect K and L to O and P, with the result that we would have coils *3, 1, 4* and *2* in parallel without disturbing the connections at Y. It is obvious that the larger the number of poles the greater would be the time saved by this method. In Fig. 14, after opening the connection between S and K, S and T would connect together, to form the R_1 lead. Leads O, P, K, and L would be connected together to form a short pitch connection. The same procedure could be followed for each of the other sections.

When a winding has three times as many coils as slots, the voltage can be reduced one-third and then one-half again, by paralleling the three coils per cell and then paralleling the sections of the winding. It is useless to try to get a four-parallel connection by paralleling the two coils in one slot and the remaining coil in this slot to one of the coils in an adjacent slot, even if the number of slots and coils permits it. The coils in the two separate slots are out of phase and would set up circulating currents and heat the motor. This was explained in the last paragraph on page 429 of the September issue of INDUSTRIAL ENGINEER, in which the first article of this series appeared.

With four coils per cell, the winding can be divided into four parallels by paralleling all the coils in one slot and if the sections of the winding are then paralleled, the equivalent of an eight-parallel connection would be obtained. In any case, to parallel the coils per slot, it is only necessary to reclip the coils at the point where the short pitch occurs.

In the third article of this series will be given tabulations that will help the winder lay out wave windings and greatly shorten the work of constructing a winding diagram.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Page Belting Company, Concord, N. H. —A 28-page booklet, entitled, "Leather Link Belting," describes and gives a number of the applications in which link leather belting may be used to advantage. These belts are made of short links of leather fastened together by pins. These links are applied on edge to the pulley. This belt is claimed to have long life and operate well under many severe operating conditions.

Mitchell - Rand Manufacturing Company, 18 Vesey Street, New York, N. Y.—Twenty-one samples of hard maple wood armature wedges are placed in an envelope with an eyelet so that it may be hung up in the shop. These samples are placed loosely in the envelope so that they may serve as gages to check the size desired for any piece of work. Formerly these were glued to a card. The size and type of each sample wedge is stamped on it. The envelope also contains a complete price list.

Superior Switchboard and Devices Company, Canton, Ohio—A 36-page booklet, entitled, "Meterology," is of handy pocket size for quick reference. It has been compiled for the aid and convenience of meter men and contains practical data and diagrams of meter and switchboard installations.

Trico Fuse Manufacturing Company, Milwaukee, Wis.—A folder describes the new Trico handy pocket-size fuse puller and replacer for all fuses up to 200 amp., 250 volt, and 100 amp., 600 volts. This is made of the highest grade genuine gray horn fiber and tested at 35,000 volts.

The Hullhorst Micro Tool Co., Toledo, Ohio—A new illustrated folder describes the construction and operation of the Hullhorst mica undercutting machines. These are made in two types: portable and for use in a lathe, on either a.c. or d.c. supply.

The Drake Electric Works, 3943 Lincoln Avenue, Chicago, Ill.—Catalog 703 describes the Drake mechanics, soldering iron with removable tips and heating element of nichrome wire wound on a lava core.

Century Electric Company, St. Louis, Mo.—Form 532 describes and illustrates several applications of Century motors for pumps and compressors.

The Cutler - Hammer Manufacturing Company, Milwaukee, Wis.—Publication 3,217 entitled, "Safety in The Rubber Mill," makes particular reference to the application of the C-H magnetic clutch brakes in rubber mills, where they are used to secure quick stopping of mixing and cracking rolls, washers and calenders when accidents occur. These can be used on any rotating machinery that must be stopped instantly, either in its operation or in an emergency.

Bird Machine Company, Pulmax Drive Division, South Walpole, Mass.—A 30-page catalog describes the "Pulmax Short Center Drive," discusses the principle of its operation and its advantages by illustrating various applications. This is a special device for increasing the arc of contact of the belt on the smaller pulley without excessive increase in tension.

The Williams Foundry and Machine Company, Akron, Ohio—Catalog 10 covers the 19 sizes of Akron friction clutches ranging from ¾ to 1,000 hp. at 100 r.p.m. The clutch is of the disk type which is applied by rollers in the toggle arm. Several pages are devoted to useful data and tables.

Reliance Electric and Engineering Company, Cleveland Ohio—Bulletin 2016 describes the Type T heavy-duty Reliance planer motors for reversing service. In addition to a complete description of the motor and its advantages a number of illustrations are given showing planer installations.

Irvington Varnish and Insulator Company, Irvington, N. J.—Catalog 101, entitled, "Irvington Insulation" describes the various insulating materials, and also the method of applying and other facts concerning the use of the different insulating varnishes.

Ohio Brass Company, Mansfield, Ohio —Circular describes the O-B 500 volt arc welder of the series resistance type which is specially designed for rail bond welding.

The O. C. White Company, Worcester, Mass.—A circular entitled "Applied Lighting" shows the various styles of adjustable wall and bench fixtures, as well as floor stands for industrial lighting.

Crouse-Hinds Company, Syracuse, N. Y. —Folder 11 describes and illustrates an interlocking switch and plug which is claimed to be 100 per cent foolproof, simple in construction and positive in action. With this it is impossible to withdraw the plug or open the door of the fuse department unless the safety switch is open and also impossible to close the switch unless the plug is fully inserted and the door of the fuse compartment is closed.

Charles Cory & Sons, Inc., 183-7 Varick St., New York, N. Y.—Catalog bulletin 50-A describes the Cory antinoise inter-communicating telephone with magnavox loud-speaking features for marine and noisy industrial applications. Bulletin 103-A describes the Cory-Recony control for electric operation of valves. Bulletin M-104A, covers the Cory signal system for electric visible signals for communicating routine instructions as may be used between important points in central stations, mines, pumping plants and other industrial fields. Bulletin 105-A describes the Cory-Robinson disconnecting switch interlock which prevents unauthorized persons from getting at the connecting switches, instrument transformers, and other disconnecting units in bus and feeder lines. Bulletin 101-29-B covers the Cory-Record ohmmeter for testing the insulation resistance of electrical apparatus, machinery and cables.

Albert & J. M. Anderson Manufacturing Company, 289-305 A Street, Boston, Mass.—Bulletin 37 describes the several kinds of automatic time switches, gives a number of the various applications and instructions for their operation.

Truscon Steel Company, Youngstown, Ohio—This literature describes a new type of steel pole for transmission and lighting purposes pressed from steel channels or I-beams.

Industrial Controller Company, Milwaukee, Wis.—Bulletin 2200-B covers alternating-current, hand-operated compensators, Type C, with oil immersed switches for starting polyphase motors. Bulletin 8527-8526 is on the alternating-current, across-the-line type of starter with low-voltage and overload protection. This may be operated from a push button station or by automatic starting devices. Bulletin 8605 describes the alternating-current automatic compensator with oil-immersed contacts for use in starting polyphase squirrel-cage motors. This is built for remote control and automatic or hand operation.

Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.—Catalog describes the apparatus and method of the hump method for the treatment of steel. This consists of the use of an electric furnace with manual control equipment, a single-point recording potentiometer to indicate the proper quenching point and a quenching tank.

Foote Bros. Gear and Machine Co., 213-221 North Curtis Street, Chicago, Ill.—A new bulletin "Foote IXL Flexible Couplings" describes, with prices and dimensions, this company's line of flexible couplings for every purpose and ranging in size from the smallest units made to couplings for transmitting several hundred horsepower. It contains much practical information on the use of flexible couplings and will be sent to anyone interested.

Electric Furnace Construction Company, Jefferson Building, Philadelphia, Pa.—A folder illustrates a number of installations of electric heat-treating, enameling furnaces, arc smelting furnaces and electric steam boilers.

Century Electric Company, St. Louis, Mo.—A folder illustrates by means of a cut-away photograph the construction of a repulsion-start, Century, single-phase induction motor. Arrows and explanatory notes point out and explain special features of construction.

Roller-Smith Company, 229 Broadway, New York, N. Y.—Bulletin 160 describes the Type GSA alternating-current portable instruments, such as ammeters, voltmeters, volt-ammeters, single-phase and polyphase wattmeters, frequency meters, power factor meters, transformers, multiplies and "Y" boxes.